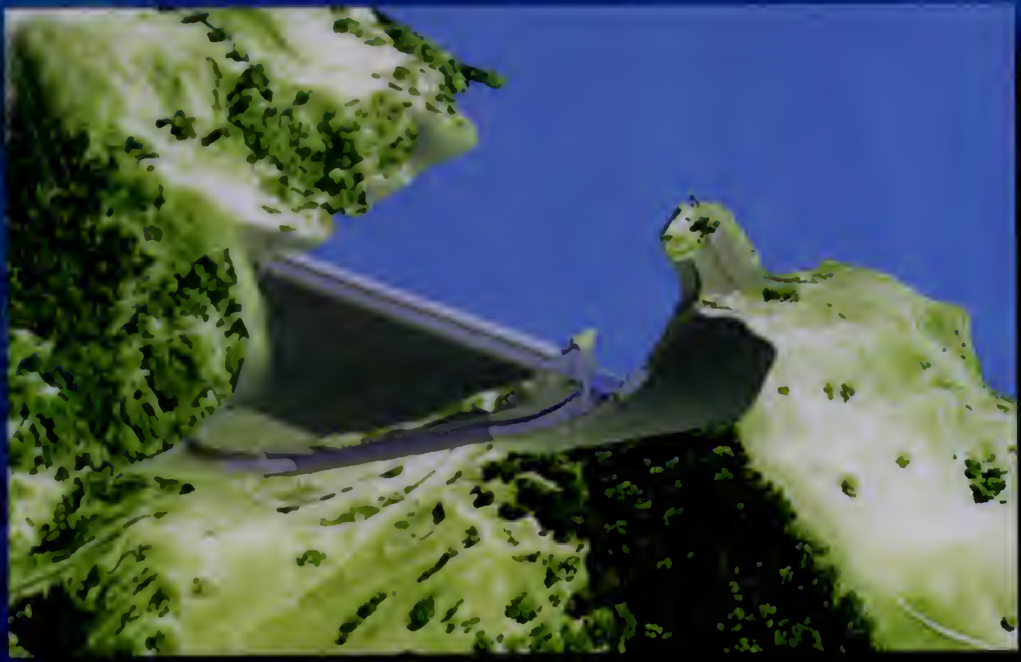
SAN FRANCISCO PUBLIC LIBRARY
3 1223 07513 5278

SFPUC
SAN FRANCISCO Public Utilities Commission

Calaveras Dam Replacement Project



FINAL Conceptual Engineering Report
Dam and Appurtenant Structures

D

REF
627.83
Ur7cr

October 31, 2005

URS

SFPUC Agreement No. CS-716

URS

October 31, 2005

Mr. David Rogers, P.E., C.E.G.
San Francisco Public Utilities Commission
1155 Market Street, 6th Floor
San Francisco, CA 94103

DOCUMENTS DEPT.
DEC - 5 2005
SAN FRANCISCO
PUBLIC LIBRARY

Subject: **Calaveras Dam Conceptual Engineering, Contract No. CS-716**
Calaveras Dam Replacement Project
Final Conceptual Engineering Report: Dam and Appurtenant Structures
File: 4110 (Task 14)

Dear Mr. Rogers:

URS is pleased to submit this Final Calaveras Conceptual Engineering Report (CER): Dam and Appurtenant Structures.

The CER is the culmination of studies that began in October 2003 and 14 technical memoranda and reports prepared by URS. The purpose of the CER is to document the results of the conceptual design (10 percent level) studies on the preferred alternative for the Calaveras Dam Replacement Project. The CER includes design criteria, summary of geotechnical conditions, fault investigations, seismic design parameters, description of the replacement dam (includes project plans, sections, and main details of the dam and appurtenant works), environmental considerations, cost estimate, and implementation schedule. Recommendations for final design studies are also presented.

This Final CER addresses comments from the Calaveras Technical Advisory Panel (CTAP) Meeting No. 4, SFPUC, and the Bay Area Water Supply & Conservation Agency (BAWSCA). The California Division of Safety of Dams (DSOD) has indicated that the proposed conceptual design of Calaveras Dam Replacement Project is acceptable.

We want to thank you and your team at SFPUC for all your help throughout the conceptual engineering studies. We look forward to working with you in completing the final design and constructing the Calaveras Dam Replacement Project.

Sincerely,

URS Corporation

Noel C. Wong
No. 32353
Exp. 12/31/06
CIVIL

Michael P. Forrest

Noel C. Wong, P.E.
Project Manager

Michael P. Forrest, P.E., G.E.
Engineering Manager

Michael Paul Forrest
No. GE319
Exp. 3-31-06.
GEOTECHNICAL

Enclosures: 25 copies of Final CER

URS Corporation
1333 Broadway, Suite 800
Oakland, CA 94612-1924
Tel: 510.893.3600
Fax: 510.874.3268

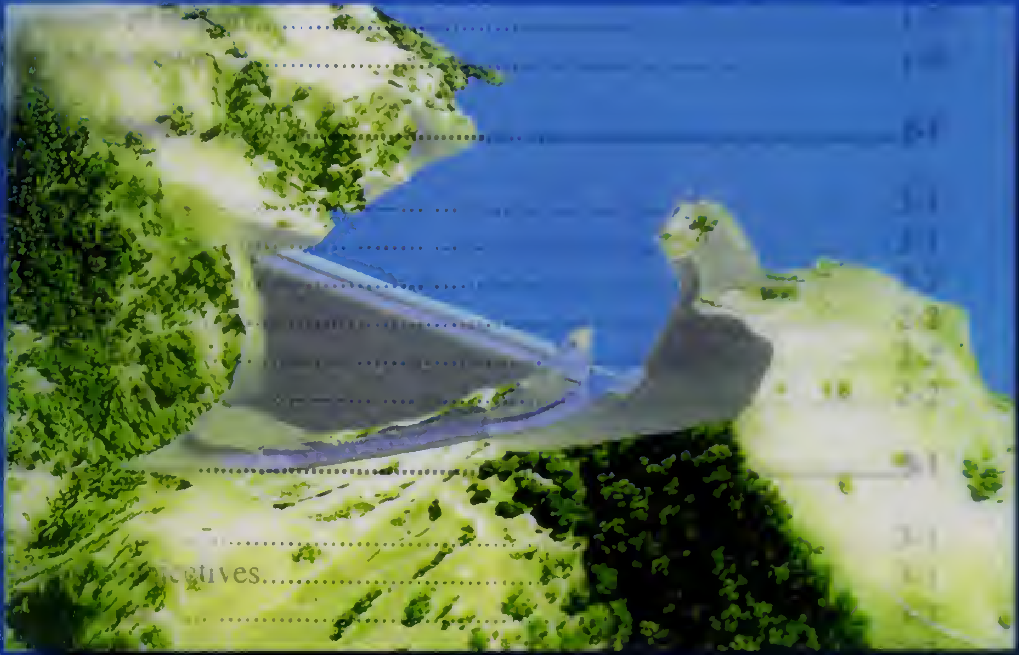
X:\x_geo\Calaveras CER\Task 14\Final CER\Final\cover ltr CER_final.doc

Digitized by the Internet Archive
in 2014

https://archive.org/details/calaverasdamrepl3120ursc

SAN FRANCISCO **Public Utilities Commission**

Calaveras Dam Replacement Project



FINAL Conceptual Engineering Report
Dam and Appurtenant Structures

October 31, 2005

URS

SFPUC Agreement No. CS-716

TABLE OF CONTENTS

Executive Summary **ES-1**
ES.1 Need for Project ES-1
ES.2 Conceptual Engineering Studies ES-1
ES.3 Recommended Project ES-2

Section 1 Introduction **1-1**

1.1 Background 1-1
1.1.1 Need for Project 1-1
1.1.2 Alternatives Evaluations and Studies Completed 1-2
1.1.3 Alternative Analysis Report (AAR) 1-4
1.1.4 Calaveras Dam Replacement Project 1-5
1.1.5 Conceptual Engineering Report (CER) 1-6
1.2 Purpose and Scope 1-7
1.3 Organization of Report 1-7
1.4 Acknowledgements 1-8

Section 2 Existing Project Facilities **2-1**

2.1 General 2-1
2.2 Dam 2-1
2.3 Spillway 2-2
2.4 Outlet Works 2-2
2.4.1 Description 2-2
2.4.2 Renovations 2-2

Section 3 Design Criteria **3-1**

3.1 General 3-1
3.2 Performance Objectives 3-1
3.3 Site Constraints 3-2
3.3.1 General 3-2
3.3.2 Landslide Hazards 3-2
3.3.3 Fault Activity and Hazards 3-3
3.4 Slope Stability 3-3
3.5 Design Flood and Freeboard 3-4
3.5.1 Design Storm and Flood 3-4
3.5.2 Freeboard 3-4
3.6 Reservoir Evacuation Requirements 3-5
3.7 Reservoir Operations 3-6
3.7.1 Normal Operations 3-6
3.7.2 Construction Flood 3-7

Section 4 Summary of Geotechnical Conditions **4-1**

4.1 Regional Geology 4-1
4.2 Calaveras Fault 4-2

TABLE OF CONTENTS

4.3 Geotechnical Investigations....................4-2
4.4 Dam Foundation....................4-3
  4.4.1 Temblor Sandstone....................4-3
  4.4.2 Franciscan Complex....................4-4
  4.4.3 Landslides....................4-5
4.5 Borrow Areas....................4-6
  4.5.1 Borrow Area A....................4-6
  4.5.2 Borrow Area B....................4-7
  4.5.3 Borrow Area C....................4-7
  4.5.4 Borrow Area D....................4-8
  4.5.5 Borrow Area E....................4-8
  4.5.6 Potential Borrow Site for Sand and Gravel....................4-9

Section 5 Summary of Fault Investigations....................5-1

5.1 Scope of Fault Investigations....................5-1
5.2 Faults In the Vicinity of Calaveras Dam....................5-2
5.3 Results of Fault Investigations....................5-3
  5.3.1 Summary....................5-3
  5.3.2 Quarry Fault....................5-3
  5.3.3 Spillway Fault....................5-4
  5.3.4 Gully Fault....................5-4
  5.3.5 Corral Point Fault....................5-4
5.4 Fault Rupture Potential In Calaveras Valley....................5-5

Section 6 Seismic Design Parameters....................6-1

6.1 Seismic Sources....................6-1
6.2 Ground Motion Parameters....................6-2
6.3 Reservoir-Triggered Seismicity....................6-2

Section 7 Description of Replacement Project....................7-1

7.1 General Site Plan....................7-1
7.2 Dam....................7-4
  7.2.1 Foundation Objectives and Treatment....................7-4
  7.2.2 Excavation....................7-5
  7.2.3 Existing Dam/Cofferdam....................7-5
  7.2.4 Embankment....................7-6
  7.2.5 Results of Stability and Deformation Analyses....................7-7
  7.2.6 Foundation Seepage Control....................7-7
  7.2.7 Stabilization of Right Abutment Landslide....................7-8
  7.2.8 Instrumentation....................7-9
7.3 Spillway....................7-10
7.4 Outlet Works....................7-10
  7.4.1 Outlet Conduit....................7-10
  7.4.2 Downstream Release Valves....................7-11

7.4.3 Intake Tower 7-11
7.5 Operation of Reservoir During Construction 7-12
7.6 Construction Considerations 7-12
7.6.1 Earthworks 7-12
7.6.2 Disposal Areas 7-13
7.6.3 Borrow Areas 7-15
7.6.4 Staging Areas 7-16
7.6.5 Imported Materials/Commercial Sources 7-16
7.6.6 Handling of Water 7-17
7.6.7 Calaveras Road Closure and Improvements 7-17
7.7 Ancillary Features 7-17
7.8 Outline Specifications 7-18
7.9 Summary of Operation and Maintenance Program 7-18

Section 8 Environmental Considerations 8-1

8.1 General 8-1
8.2 Biological Resources 8-1
8.2.1 Dam Site, Staging Areas, and Spillway 8-2
8.2.2 Borrow Areas 8-3
8.2.3 Disposal Areas 8-3
8.2.4 Haul Roads 8-4
8.2.5 Calaveras Road Improvements 8-4
8.2.6 Inundation Area 8-4
8.3 Cultural Considerations 8-5
8.3.1 Dam Site, Staging Areas, and Spillway 8-5
8.3.2 Borrow Sites 8-6
8.3.3 Disposal Sites 8-6
8.3.4 Haul Roads 8-7
8.3.5 Calaveras Road Improvements 8-7
8.3.6 Inundation Area 8-7
8.4 Construction Traffic and Road Closure 8-8
8.5 Water Quality 8-8

Section 9 Cost Estimate 9-1

9.1 General 9-1
9.2 Capital Cost 9-1
9.2.1 Construction Cost 9-2
9.2.2 Design Contingency 9-3
9.2.3 Construction Contingency 9-3
9.2.4 Project Delivery Cost 9-3
9.2.5 Environmental Mitigation Costs 9-4
9.3 Life Cycle Costs 9-4

TABLE OF CONTENTS

Section 10 Implementation Schedule 10-1

10.1 Summary 10-1
10.2 Critical Path Activities 10-1
10.3 Implementation Schedule 10-2

Section 11 Conclusions and Recommendations 11-1

11.1 Conceptual Design 11-1
  11.1.1 Recommended Project 11-1
  11.1.2 Foundation Conditions and Borrow Materials 11-3
  11.1.3 Faults In the Dam Site Vicinity 11-3
  11.1.4 Seismic Ground Motion Parameters 11-3
  11.1.5 Replacement Dam 11-4
  11.1.6 Environmental Considerations 11-4
  11.1.7 Estimated Capital Cost and Project Schedule 11-4
11.2 Recommendations for Final Design 11-5
  11.2.1 Final Design Investigations 11-5
  11.2.2 Final Design Engineering 11-6
  11.2.3 Path Forward 11-6

Section 12 References 12-1

Section 13 Glossary of Terms 13-1

Tables

Table 2-1 Description of Calaveras Dam and Appurtenant Works
Table 3-1 Loading Conditions and Stability Criteria
Table 3-2 Inflow Events
Table 3-3 Construction Flood Routing Results
Table 4-1 Unconfined Compressive Strengths (UCS) of Temblor Sandstone
Table 4-2 Unconfined Compressive Strengths (UCS) of Franciscan Rocks
Table 4-3 Estimated In-Situ Borrow Area Quantities
Table 5-1 DSOD Fault Activity Guidelines (from Fraser, 2001)
Table 5-2 Summary of Results of Fault Investigations
Table 7-1 Description of Replacement Calaveras Dam and Appurtenant Works
Table 7-2 Rock Weathering/Alteration
Table 7-3 Estimated Dam Foundation Levels
Table 7-4 Summary of Instrumentation
Table 7-5 Summary of Disposal Areas
Table 7-6 Estimated Borrow Material Quantities
Table 9-1 Project Cost Estimate Summary

Figures

Figure 1-1 Site Vicinity Map
Figure 2-1 Locations of Existing Project Components
Figure 2-2 Reservoir Plan and Area-Capacity Curves
Figure 2-3 Existing Dam - Plan and Center Cross-Section
Figure 3-1 PMP Rainfall Hyetograph, PMF Inflow and Outflow Hydrographs and Reservoir Elevation
Figure 3-2 Open Channel Spillway Discharge Rating Curve
Figure 3-3 Existing Outflow Capacity Curve
Figure 4-1 Regional Geologic Map Showing Major Faults of the San Andreas Fault System in the San Francisco Bay Area
Figure 4-2 Major Active Faults in the Southern San Francisco Bay Region with Boundaries of Calaveras Fault Segments
Figure 4-3 Generalized Fault Map of the Calaveras Valley Area
Figure 4-4A Geologic and Exploration Location Plan, Calaveras Dam Site
Figure 4-4B Geologic and Exploration Location Plan, Calaveras Dam Site

Figure 4-4C Geologic and Exploration Location Plan, Calaveras Dam Site
Figure 4-4D Geologic and Exploration Location Plan, Calaveras Dam Site
Figure 4-5 Limits of Potential Borrow Areas Plan
Figure 5-1 Faults in the Vicinity of Calaveras Reservoir
Figure 5-2 Locations of Identified Faults and Fault Trenches
Figure 5-3 Generalized Geologic Map of the Quarry Fault Trench Site
Figure 5-4 Generalized Geologic Map of the Spillway Fault Trench Site
Figure 5-5 Topographic Map of Corral Point Area Trench Site
Figure 5-6 Calaveras and Corral Point Faults in the Northern Part of Calaveras Reservoir
Figure 6-1 84th Percentile Acceleration Response Spectra for the **M** 7¼ Calaveras Fault MCE Adjusted for Directivity
Figure 6-2 Recommended MCE Fault Parallel Time Histories
Figure 7-1 Locations of Proposed Project Components
Figure 7-2 Site Plan
Figure 7-3 Embankment and Spillway Plan
Figure 7-4 Embankment Dam Sections
Figure 7-5 Embankment Dam and Spillway Profiles
Figure 7-6 Embankment Dam Details
Figure 7-7 Instrumentation Plan
Figure 7-8 New Intake Tower Plan and Sections
Figure 7-9 Material Balance Diagram
Figure 8-1 Special Status Species Habitats and Known Occurrences in the Study Area
Figure 8-2 Cultural Resources - Sensitivity Areas
Figure 10-1 Calaveras Dam Replacement Project Implementation Schedule

Appendices

Appendix A Transition Memorandum: Development of Calaveras Dam Replacement Project (01CUW37401-A)
Appendix B Reservoir Operations Plan
Appendix C Special Status Species with Potential to Occur in the Project Area
Appendix D Stability and Seismic Deformation Analyses of Replacement Dam
Appendix E Outline Specifications
Appendix F Construction Cost Estimate and Schedule

Appendix G Responses to Comments from CTAP Meeting No. 4 and SFPUC
Appendix H DSOD Letter of July 13, 2005
Appendix I Response to Comments from Bay Area Water Supply & Conservation Agency (BAWSCA)

ES.1 NEED FOR PROJECT

Calaveras Dam and Reservoir are significant components of the San Francisco Public Utilities Commission (SFPUC) Regional Water System. As constructed in 1925, Calaveras Dam allows for retention of about 96,850 acre-feet (31 billion gallons)[1] of local runoff in Alameda County. It is the SFPUC's largest local reservoir, providing about 40 percent of the SFPUC's local water storage. As such, Calaveras Dam represents a high priority and one of the most important projects of the Water System Improvement Program (WSIP).

Since the winter of 2001, in response to safety concerns about the seismic stability of the dam and mandates from the California Division of Safety of Dams (DSOD), the SFPUC has lowered water levels in Calaveras Reservoir to about elevation 705, or approximately 39 percent of its maximum capacity. The DSOD has indicated that it is allowing this interim operating level to accommodate the SFPUC's water needs, with the understanding that the SFPUC would pursue an aggressive schedule to alleviate the safety concerns about Calaveras Dam.

Maintaining Calaveras Reservoir at the interim water level has reduced the storage capacity and the quality of the stored water. This reduction in storage capacity has impacted the overall SFPUC system operations and reliability as highlighted by events surrounding the break in San Joaquin Pipeline No. 3 in 2003 that significantly reduced normal Hetch Hetchy supply. To compensate for reduced Hetch Hetchy supply, local water usage, including Calaveras Reservoir, had to be increased. At the same time, low water levels at Calaveras since storage restriction created conditions for increased algae growth, leading to taste and odor issues in the final treated water. In addition, the 1997 Memorandum of Understanding between SFPUC and the California Department of Fish and Game (CDFG) to release up to 6,300 acre-feet per year of water for the enhancement of fisheries and other natural resources of Calaveras and Alameda Creeks has not been fully implemented because of the current limitations in storage. In brief, the SFPUC will continue to have water supply, water quality, and reliability issues until a suitable solution is identified and implemented for Calaveras Dam.

ES.2 CONCEPTUAL ENGINEERING STUDIES

Conceptual Engineering studies to repair or to replace Calaveras Dam were carried out by a SFPUC and URS Corporation (URS) project team since October 2003. As different study tasks were completed, the results were reviewed by the Calaveras Technical Advisory Panel (CTAP), DSOD and SFPUC's Management Steering Committee. The following are some highlights of the studies completed:

- A geotechnical investigation program including field explorations and laboratory testing was conducted to investigate foundation conditions at the dam and availability of materials in borrow areas. A site downstream of the existing dam is found to be suitable for construction of an earthfill dam and sufficient materials are available on site for the main zones of the dam.

---

[1] 96,850 acre-feet is the storage capacity of the reservoir when first constructed in 1925. Over the last 80 years, sedimentation within the reservoir from the surrounding drainages, principally Arroyo Hondo, has reduced reservoir capacity to approximately 92,000 acre-feet, based on bathymetric surveys by SFPUC in 2000.

- A detailed investigation and assessment of the activity of faults near Calaveras Dam was also completed. The Quarry and Spillway faults, which are within the dam site, were concluded to be inactive, and provided the basis to develop appropriate design parameters for the project.
- SFPUC adopted project design criteria that will provide for a robust design that can accommodate Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE) seismic loading conditions.
- The MCE is a moment magnitude (**M**) 7¼ earthquake on the central Calaveras fault at a distance of 0.5 km (0.3 miles) from the dam site, and was developed using a deterministic approach as required by DSOD.
- Conceptual engineering and design studies were initiated to address alternatives for remediating the existing dam or construction of a new replacement dam and appurtenances to restore the reservoir to its original storage capacity or to an enlarged capacity.
- A number of biological and cultural resources considerations related to the replacement dam have been identified. To the extent practical, they have been avoided or minimized. Formal evaluations of impacts associated with construction will have to be completed, and mitigation measures that would satisfy regulatory requirements will have to be developed and included in the project.
- In accordance with SFPUC Procedure No. PD 3.3, an Alternatives Analysis Report (AAR) was prepared. The alternatives that were identified and screened were analyzed and evaluated based on the five following criteria:
  - environmental impacts;
  - operational flexibility, maintainability, and reliability;
  - implementability;
  - cost; and
  - dam safety approval.
- The results of the Alternative Analysis indicate that regardless of the size of the reservoir, or single versus staged construction (i.e., a larger reservoir constructed in stages), the preferred alternative is to:
  - replace instead of remediate the existing dam,
  - with a new earthfill dam,
  - located downstream of the existing dam,
  - with an open-chute spillway.
- The existing dam will function as a cofferdam for construction of the replacement dam.

ES.3 RECOMMENDED PROJECT

In late 2004, a thorough review of SFPUC's capital improvement program was completed by SFPUC Commissioners and senior management. Specific overall program goals for seismic reliability, water quality, water supply and delivery reliability were identified. The originally proposed regional projects, including Calaveras Dam, were evaluated, and the WSIP was developed and approved by the Commissioners at SFPUC on February 8, 2005.

As part of this overall program review and re-scoping, additional project definitions and directives were developed by the SFPUC. The recommended Calaveras Dam Replacement Project will include the following:

- Replacement of the existing dam with a new dam located downstream of the existing dam.
- The new dam would have a nominal reservoir storage of 96,850 acre-feet (normal maximum water surface, NMWS, elevation = 756 feet). This storage is the same as the storage capacity of the reservoir when first constructed in 1925.
- The new dam would accommodate enlargement up to 386,000 acre-feet[2] (NMWS elevation = 890 feet[3]) as described below.
- The project will include a new intake tower for seismic safety, improved operations and maintenance, and accommodations for releases for environmental purposes.
- Additionally, the project was to include a second pipeline from the new dam to the Sunol Valley Water Treatment Plant (SVWTP) to provide an additional 70 MGD of capacity to the 90 MGD of the existing pipeline, and allow the full utilization of the SVWTP treatment capacity to supply 160 MGD from Sunol Valley in the event of a Hetch Hetchy outage. However, alternative analysis completed since the approval of the WSIP in February 2005 indicates that the goal to supply 160 MGD from Sunol Valley during a Hetch Hetchy outage need not involve the construction of a new pipeline from the new Calaveras Dam. The preferred alternative involves utilizing existing facilities and improvements with the San Antonio Pump Station and San Antonio Pipeline. As such, the proposed Calaveras Dam Replacement Project no longer includes the component of Conveyance Facilities.

One of the design parameters calls for the potential inclusion of the dam in a larger dam in the future. This concept resulted from the realization that costs to achieve this purpose are minimal compared with costs to construct a replacement dam that does not have the ability to be enlarged. In order to address this in the design, an upper limit on the size of a future reservoir had to be identified. Since there is no knowledge of whether there will be a future need for Calaveras Reservoir to be larger than the proposed 96,850 acre-feet (and if there will be a need, what size it would be), an engineering solution to the question of reservoir size was evaluated. It was determined that a reasonable upper limit on the elevation of a future reservoir would be 890 feet, which is the elevation of the Alameda Creek Diversion Tunnel intake. This is the highest reservoir elevation that would not require modification of the diversion facilities. If a reservoir at elevation 890 were to be built in the future, it would have a storage capacity of approximately 386,000 acre-feet.

Based on the conceptual design completed (10 percent design), the estimated construction cost is $143,780,000 (4th quarter 2005 dollars). The total estimated Project Budget, escalated to the midpoint of construction, would be $272,595,000. Besides the construction cost, the Project

---

[2] Core and filter dimensions within the new dam will be constructed to accommodate enlargement of the dam to 386,000 acre-feet.

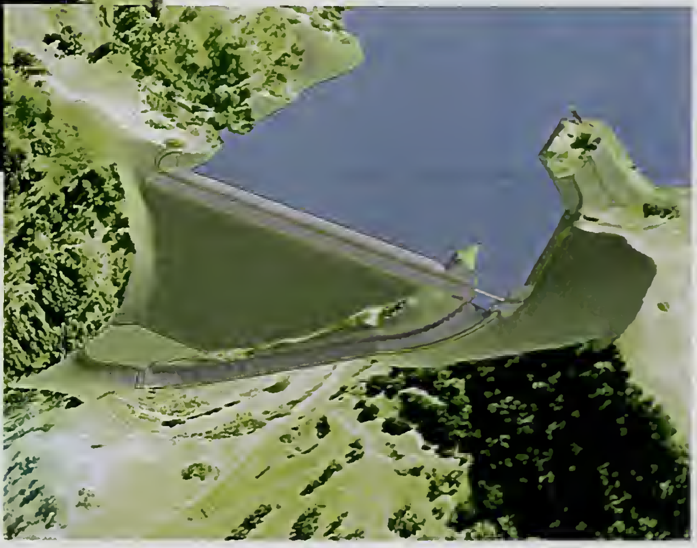
[3] Approximate invert elevation of the Alameda Creek Diversion Tunnel.

Budget includes construction contingency, environmental mitigation costs, and project delivery costs.

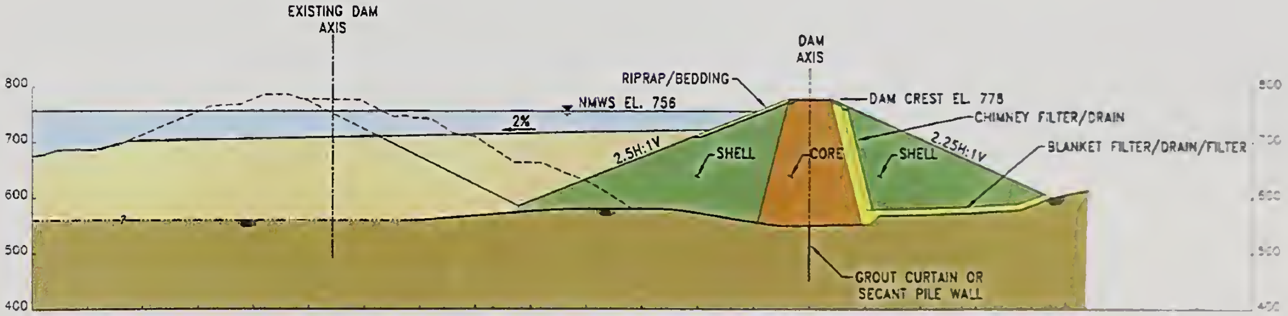
The DSOD has indicated that the proposed conceptual design of Calaveras Dam Replacement Project is acceptable. SFPUC is pursuing an aggressive schedule for the Environmental Review and Design phases of this project. Construction would commence in early 2009 with project completion in mid-2011. From an engineering and construction standpoint, the project completion date could be accelerated. However, schedule acceleration may be limited by the environmental documentation and review process.

Final design work will need to include geotechnical investigations in the dam and spillway foundation, new intake tower, and borrow areas. Also, final design engineering will further refine and optimize layouts of the foundation and spillway excavations and dam design; spillway hydraulic modeling; materials handling evaluations; foundation seepage control system; and stability and seismic deformation analyses.

Existing Dam



View of Proposed Calaveras Dam Replacement


EXISTING DAM
AXIS
DAM
AXIS
800
700
600
500
400
RIPRAP/BEDDING
NMWS EL. 756
2%
DAM CREST EL. 778
CHIMNEY FILTER/DRAIN
2.5H:1V
SHELL
CORE
SHELL
2.25H:1V
BLANKET FILTER/DRAIN/FILTER
GROUT CURTAIN OR
SECANT PILE WALL
800
700
600
500
400

Section Through Dam

KEY POINTS

- Calaveras Reservoir is the largest local reservoir in the San Francisco Public Utilities Commission (SFPUC) Regional Water System and its original storage is 96,850 acre-feet.
- The 210-foot-high Calaveras Dam was completed in 1925. In 2001, in response to concerns of the California Division of Safety of Dams (DSOD) about the seismic stability of the dam, SFPUC lowered the Calaveras Reservoir to a maximum level corresponding to 38,100 acre-feet, approximately 39 percent of its original maximum capacity.
- Maintaining Calaveras Reservoir at the interim water level has reduced the storage capacity and the quality of the stored water and has impacted the overall SFPUC system operations and reliability. Low water levels have created conditions for increased algae growth, leading to taste and odor issues in the final treated water. In addition, the 1997 Memorandum of Understanding between SFPUC and the California Department of Fish and Game (CDFG) to release up to 6,300 acre-feet per year of water for the enhancement of fisheries and other natural resources of Calaveras and Alameda Creeks has not been fully implemented because of the current limitations in storage. The SFPUC will continue to have water supply, water quality, and reliability issues until a suitable solution is identified and implemented for Calaveras Dam.
- Conceptual engineering and design studies were initiated to address alternatives for remediating the existing dam or construction of a new replacement or enlarged dam and appurtenances to restore the reservoir to its original intended function (with a nominal storage capacity of 96,850 acre-feet) or to provide for an enlarged reservoir.
- The results of the alternatives evaluation were documented in an alternatives analysis report (AAR). The AAR concluded that the preferred alternative is a replacement earthfill dam located downstream of the existing dam with an open chute spillway. The dam design includes the ability for enlargement for future generations.
- The supporting reports and technical memoranda for this Conceptual Engineering Report (CER) have been reviewed by SFPUC, DSOD and the Calaveras Technical Advisory Panel (CTAP) since the project began in October 2003.

1.1 BACKGROUND

1.1.1 Need for Project

The San Francisco Public Utilities Commission (SFPUC) is undertaking a Water System Improvement Program (WSIP) developed to address issues of system reliability. Maintaining sufficient local water storage is a critical element to provide for a reliable supply and general emergency preparedness for the SFPUC system.

Located in the eastern San Francisco Bay region south of Sunol and east of Milpitas, Calaveras Dam and Reservoir are significant components of the SFPUC Regional Water System (see site location on Figure 1-1). As originally constructed in 1925, Calaveras Dam allows for retention of about 96,850 acre-feet (31 billion gallons)[4] of local runoff in Alameda County. It is the SFPUC's largest local reservoir, providing about 40 percent of the SFPUC's local water storage. As such, the Calaveras Dam Replacement Project represents a high priority and one of the most important projects of the WSIP.

Since the winter of 2001, in response to safety concerns about the seismic stability of the dam and mandates from the California Division of Safety of Dams (DSOD), the SFPUC has lowered water levels in Calaveras Reservoir to about elevation 705, or approximately 39 percent of its maximum capacity[5]. The DSOD has indicated that it is allowing this interim operating level to accommodate the SFPUC's water needs, with the understanding that the SFPUC would pursue an aggressive schedule to alleviate the safety concerns about Calaveras Dam. Maintaining Calaveras Reservoir at the interim water level has reduced the storage capacity and the quality of the stored water. This reduction in storage capacity has impacted the overall SFPUC system operations and reliability as highlighted by events surrounding the break in San Joaquin Pipeline No. 3 in 2003 that significantly reduced normal Hetch Hetchy supply. To compensate for reduced Hetch Hetchy supply, local water usage, including Calaveras Reservoir, had to be increased. At the same time, low water levels at Calaveras since storage restriction created conditions for increased algae growth, leading to taste and odor issues in the final treated water. In addition, the 1997 Memorandum of Understanding between SFPUC and the California Department of Fish and Game (CDFG) to release up to 6,300 acre-feet per year of water for the enhancement of fisheries and other natural resources of Calaveras and Alameda Creeks has not been fully implemented because of the current limitations in storage. In brief, the SFPUC will continue to have water supply, water quality, and reliability issues until a suitable solution is identified and implemented for Calaveras Dam.

1.1.2 Alternatives Evaluations and Studies Completed

Because of the original hydraulic fill dam construction and the close proximity of the dam to the Calaveras fault, strong ground motions generated during a large earthquake on the fault could impact the stability of the existing dam. Since October 2003, the SFPUC has retained URS Corporation to provide professional engineering services for the conceptual engineering phase of the Calaveras Dam Project (SFPUC Agreement No. CS-716). The work includes the evaluation of alternatives to repair the existing Calaveras Dam or replace the dam with one of equal or enlarged capacity. Three main categories of alternatives have been studied:

- Category 1: Remediate or replace dam for the same reservoir storage - 96,850 acre-feet (normal maximum water surface elevation 756 feet[6]).
- Category 2: Remediate or replace dam for increased reservoir storage - up to 420,000 acre-feet (normal maximum water surface up to elevation 900 feet).

---

[4] 96,850 acre-feet is the storage capacity of the reservoir when first constructed in 1925. Over the last 80 years, sedimentation within the reservoir from the surrounding drainages, principally Arroyo Hondo, has reduced reservoir capacity to approximately 92,000 acre-feet, based on bathymetric surveys by SFPUC in 2000.

[5] The reservoir storage was initially restricted to elevation 699 feet in 2001 and was later changed to elevation 705 feet in 2003 after DSOD's review of the Final Report on the Seismic Stability of Calaveras Dam.

[6] Elevations in this report are based on USGS datum. Subtract 3.636 feet to convert to San Francisco Water Department (Crystal Springs) datum.

- Category 3: Remediate or replace dam for the same reservoir storage (96,850 acre-feet) and retain option for future enlargement (up to a total of 420,000 acre-feet). In this regard, the alternatives evaluated in Category 3, prior to enlargement, are similar to those in Category 1.

The maximum storage capacity of 420,000 acre-feet is based on considerations of the active Calaveras fault (URS, 2004a). The fault passes through a low saddle located west of the dam site and limits the maximum reservoir level. It is not considered feasible to construct a saddle dam across the active Calaveras fault.

Alternatives were evaluated for the above three categories. Specifically:

- alternative dam, spillway, and outlet concepts were evaluated;
- conceptual level designs, cost estimates, and construction schedules were prepared; and,
- a proposed preferred alternative is recommended for each of the above categories.

For the remediation alternative, the existing dam would be retained and become a part of the water retention structure. The remediation alternatives considered for conceptual engineering studies include buttressing and buttressing combined with soil improvement.

For a replacement or large dam alternative, a new dam would be constructed as the water retention structure. The dam replacement alternatives could be located downstream of or within the existing dam area. The following four replacement and enlargement dam types were considered for conceptual engineering studies: earthfill or earth- and rockfill dam; concrete-face rockfill dam; asphalt concrete core rockfill dam; and roller compacted concrete dam

URS completed conceptual-level geologic and geotechnical investigations during the period of October 2003 through March 2004 and in August 2004. A Geotechnical Data Report (GDR) (URS, 2005a) presents the results of these investigations and provides a characterization of the soil, rock and groundwater conditions of the downstream dam foundation and borrow areas, and geologic mapping of the reservoir rim landslides and conveyance pipeline corridor between the existing Calaveras Dam and the Sunol Valley Water Treatment Plant (SVWTP). A Geotechnical Interpretive Report (GIR) (URS, 2005b) integrating and interpreting the data in the GDR was completed for use during conceptual engineering design studies.

Seismic studies were conducted for the purpose of evaluating fault rupture potential [Technical Memorandum (TM) 6.2, WLA/URS, 2005] and to characterize seismically induced ground motions (TM 6.3, URS, 2005c) at the site for conceptual design of remediation and replacement dam alternatives.

Alternatives evaluation and general design criteria are discussed in URS (2004a). Evaluations of remedial alternatives and formulation of conceptual designs for proposed preferred alternatives are presented in the Evaluation of Remedial Design Alternatives for Existing Dam, Draft TM 9.1 (URS, 2004c). Preliminary screening of replacement dam type alternatives and formulation of conceptual designs for those alternatives that passed the screening are presented in the Evaluation of Replacement and Enlarged Dam Alternatives, Draft TM 9.2 (URS, 2004d). Spillway and Outlet Works, Draft TM 7.0 (URS, 2004b) presents considerations for hydraulic structures associated with the various remedial and replacement dam alternatives. Evaluation of storage and bypass requirements during construction is presented in Operation of Reservoir/Storage and Bypass Requirements During Construction, Draft TM 11.1 (URS, 2004e).

Construction cost estimates and schedules for selected remediation and replacement dam alternatives are presented in TM 13 (URS, 2005d). Environmental considerations including community disruption, biological issues, cultural issues, and water quality issues related to the alternatives are presented in TM 8 (URS, 2005f).

The conceptual design of the remediation and replacement dam alternatives were presented to the CTAP on July 27-29, 2004, and to DSOD on August 26, 2004. Comments received from the CTAP and DSOD were incorporated, where applicable, in the alternatives analysis and evaluation.

KEY DOCUMENTS PREPARED DURING CONCEPTUAL ENGINEERING

- Geotechnical Data Report (URS, 2005a)
- Geotechnical Interpretive Report (URS, 2005b)
- Investigation of Fault Rupture Potential (Task 6.2) (WLA/URS, 2005)
- Seismic Source Characterization and Deterministic Ground Motion Assessment (Task 6.3) (URS, 2005c)
- Calaveras Test Site Hazardous Waste Evaluation (Task 5.2) (URS, 2004f)
- Commercial Materials Source Assessment (Task 5.3) (URS, 2005e)
- Alternatives Evaluation and General Design Criteria, Dam and Appurtenant Works (Task 2.0) (URS, 2004a)
- Spillway and Outlet Works (Task 7.0) (URS, 2004b)
- Evaluation of Remedial Design Alternatives for Existing Dam (Task 9.1) (URS, 2004c)
- Evaluation of Replacement and Enlarged Dam Alternatives (Task 9.2) (URS, 2004d)
- Operation of Reservoir/Storage and Bypass Requirements During Construction (Task 11.1) (URS, 2004e)
- Environmental Constraints Evaluation of the Proposed Dam Alternatives (Task 8.0) (URS, 2005f)
- Cost Estimates of Alternatives (Task 13) (URS, 2005d)
- Evaluation of Dam Remediation and Replacement Alternatives (Task 9.3) (URS, 2005g)

1.1.3 Alternative Analysis Report (AAR)

The results of the alternative analyses and evaluations, and recommendations of proposed preferred alternatives were presented in TM 9.3 - Evaluation of Dam Remediation and Replacement Alternatives (URS, 2005g). The approach, analysis and information presented in this TM are based on SFPUC Procedure No. PD 3.3, Alternatives Analysis and Evaluation, dated August 18, 2003. Comments received from CTAP and DSOD on the work presented in the reports and technical memoranda listed above were incorporated, where applicable, in the preparation of TM 9.3.

The contents of TM 9.3 fulfill the requirements of an Alternative Analysis Report (AAR) specified in Procedure No. PD 3.3. As such, TM 9.3 is considered the equivalent of an AAR. As summarized in TM 9.3, alternatives analyses were conducted considering the five following criteria:

- environmental impacts,
- operational flexibility, maintainability, and reliability,
- implementability,
- cost, and
- dam safety approval.

Each of the criteria was broken into definable contents that could be quantified for comparison of the alternatives in a matrix format. A ranking system consisting of criteria weighting factors and scoring rationale was developed to provide a rational basis for evaluating the alternatives within the project categories to assist in identifying the proposed preferred alternative. The scoring rationale and weighting factors were applied to the results of the alternative analysis for the project categories.

The results indicate that for Category 1 a downstream earthfill replacement dam (1Ca) has the highest ranking. The earth- and rockfill dam (2Cb) has the highest ranking for Category 2. In Category 3, the preferred alternative is a downstream earthfill replacement dam with open spillway (3Ca).

Essentially, the results indicate that regardless of (1) the size of the reservoir, i.e., Category 1 versus Categories 2 or 3; or (2) single versus staged separate construction, i.e., Category 1 or 2 versus Category 3, the preferred alternative is to:

- replace instead of remediate the existing dam,
- with a new earth- or earth/rock-fill dam,
- located downstream of the existing dam,
- with an open-chute spillway.

The AAR and the above findings presented to the CTAP on November 1-2, 2004, and to the DSOD on December 16, 2004. Based on the general concurrence received from the CTAP and DSOD, the AAR and the findings were presented to the SFPUC Management Steering Committee on December 21, 2004.

1.1.4 Calaveras Dam Replacement Project

Additional project definitions and directives were developed by the SFPUC in late 2004. Appendix A presents a memorandum that describes the development of the Calaveras Dam Replacement Project.

In brief, a thorough review of SFPUC's capital improvement program was completed by SFPUC Commissioners and senior management. Specific overall program goals for seismic reliability, water quality, water supply and delivery reliability were identified. The originally proposed regional projects, including the Calaveras Dam Project, were evaluated, and a new Water System

Improvement Program (WSIP) was developed and approved by the Commissioners at SFPUC on February 8, 2005.

As part of this overall program review and re-scoping, the scope of the Calaveras Dam Replacement Project will include the following:

- Replacement of the existing dam with a new dam located downstream of the existing dam.
- The new dam would have a nominal reservoir storage of 96,850 acre-feet (normal maximum water surface elevation, NMWS, elevation = 756 feet). This storage is the same as the storage capacity of the reservoir when first constructed in 1925.
- The new dam would accommodate enlargements up to 386,000 acre-feet (NMWS elevation = 890 feet, which is the elevation of the Alameda Creek Diversion tunnel intake).
- The project will include new or rehabilitated outlet works for seismic safety, improved operations and maintenance, and accommodations for releases for environmental purposes.
- Additionally, the project was to include a second pipeline from the new dam to the Sunol Valley Water Treatment Plant (SVWTP) to provide an additional 70 MGD of capacity to the 90 MGD of the existing pipeline, and allow the full utilization of the SVWTP treatment capacity to supply 160 MGD from Sunol Valley in the event of a Hetch Hetchy outage. However, alternative analysis completed since the approval of the WSIP in February 2005 indicates that the goal to supply 160 MGD from Sunol Valley during a Hetch Hetchy outage need not involve the construction of a new pipeline from the new Calaveras Dam. The preferred alternative involves utilizing existing facilities and improvements with the San Antonio Pump Station and San Antonio Pipeline (CDM/URS, 2005). As such, the proposed Calaveras Dam Replacement Project no longer includes the component of Conveyance Facilities.

One of the design parameters calls for the potential inclusion of the dam in a larger dam in the future. This concept resulted from the realization that costs to achieve this purpose are minimal compared with costs to construct a replacement dam that does not have the ability to be enlarged. In order to address this in the design, an upper limit on the size of a future reservoir had to be identified. Since there is no knowledge of whether there will be a future need for Calaveras Reservoir to be larger than the proposed 96,850 acre-feet (and if there will be a need, what size it would be), an engineering solution to the question of reservoir size was evaluated. It was determined that a reasonable upper limit on the elevation of a future reservoir would be 890 feet, which is the elevation of the Alameda Creek Diversion Tunnel intake. This is the highest reservoir elevation that would not require modification of the diversion facilities. If a reservoir at elevation 890 were to be built in the future, it would have a storage capacity of approximately 386,000 acre-feet.

1.1.5 Conceptual Engineering Report (CER)

The AAR and the scope of the Calaveras Dam Replacement Project were discussed and general concurrence was reached during a SFPUC Management Steering Committee Meeting on March 1, 2005. The AAR/TM 9.3 (URS, 2005g) is considered adequate to address the needs of the alternative analysis and evaluation of the Calaveras Dam Replacement Project. The AAR served as a basis for the preparation of the Conceptual Engineering Report (CER) for the Project. The project team was tasked to move forward immediately with the completion of Calaveras Dam Replacement Project CER.

The CER was to consist of two volumes: Volume I - Dam and Appurtenant Structures; and Volume II - Conveyance Facilities. However, as discussed in Section 1.1.4, the proposed Calaveras Dam Replacement Project no longer includes the component of Conveyance Facilities, and as such, there will not be a CER - Volume II for the Project.

The draft CER Volume I was submitted on April 25, 2005. This final CER incorporates responses to comments from CTAP Meeting No. 4 (May 10-11, 2005) and SFPUC on the draft CER. The comments and responses are presented in Appendix G. The DSOD reviewed the draft CER and provided their comments in a letter on July 13, 2005, which is included in Appendix H. The Bay Area Water Supply & Conservation Agency (BAWSCA) also provided review comments of the draft CER and responses to their comments are included in Appendix I.

1.2 PURPOSE AND SCOPE

The purpose of the CER is to document the results of the studies summarized in Section 1.1 on the preferred alternative for the Calaveras Dam Replacement Project. The scope of work for the CER documents the conceptual design (10 percent level) of the preferred alterative and includes design criteria, summary of geotechnical conditions, fault investigations, seismic design parameters, description of the replacement dam (includes project plans, sections, and main details of the dam and appurtenant works), environmental considerations, cost estimate, and implementation schedule. Recommendations for final design studies[7] are also presented.

1.3 ORGANIZATION OF REPORT

The contents of this conceptual engineering report were developed based on SFPUC Procedure No. PD 3.4, Conceptual Engineering Report, dated August 18, 2003. After this introductory section, this report includes the following sections:

- **Section 2** describes the existing project facilities.
- **Section 3** describes the design criteria used for the new project facilities.
- **Section 4** summarizes the geotechnical conditions at the project site.
- **Section 5** presents the results of fault investigations at the site.
- **Section 6** presents the seismic design parameters used for dam design.
- **Section 7** describes the design of the replacement dam and appurtenant structures.
- **Section 8** describes environmental considerations for the project.
- **Section 9** presents the conceptual construction cost estimate for the project.
- **Section 10** presents the project implementation schedule.
- **Section 11** presents conclusion and recommendations.

---

[7] The term “final design” as used in this CER encompasses both detailed design (“35%” level) and final design (“65%”, “95%” and “100%” levels).

- **Section 12** presents pertinent references.
- **Section 13** presents a glossary of terms used in the report.
- **Appendix A** presents a memorandum describing the transition of the project from the recommended alternative determined in the AAR to the Calaveras Dam Replacement Project.
- **Appendix B** presents the Reservoir Operations Plan.
- **Appendix C** presents Special Status Species with Potential to Occur in the Project Area.
- **Appendix D** presents the results of stability and deformation analyses for replacement dam.
- **Appendix E** presents outline specifications for the project facilities.
- **Appendix F** presents the cost estimate and construction schedule.
- **Appendix G**[8] presents responses to comments from CTAP Meeting No. 4, and SFPUC on the draft CER
- **Appendix H** includes the DSOD letter of July 13, 2005, on the review of the conceptual design of the Calaveras Dam Replacement Project.
- **Appendix I** presents responses to comments from the Bay Area Water Supply & Conservation Agency (BAWSCA) on the draft CER.

1.4 ACKNOWLEDGEMENTS

This CER was prepared with the participation of many SFPUC and URS Project Team members.

Valuable assistance and review were received from a number of individuals at the SFPUC including Chris Nelson, Barbara Palacios, David Rogers, Gilbert Tang, Chu Liu, Craig Freeman, Janice Hutton, and Leo Bauer.

The URS team contributors for the technical studies include the following:

- Geotechnical investigations: Mark Schmoll, Phil Respess, and Mark McKee (Robert Y. Chew Geotechnical, Inc.)
- Fault investigations: Keith Kelson and Robert Witter (William Lettis and Associates)
- Seismic design parameters: Ivan Wong, Paul Somerville, and Lelio Mejia
- Dam design: David Hughes, John Roadifer, Theodore Feldsher, and Nikolai Meyer
- Hydraulic structures design: Gregory Reichert and Chris Mueller
- Stability and seismic deformation analyses: Segaran Logeswaran, Rajendram Arulnathan, and Lelio Mejia
- Environmental considerations: Steve Leach, Brian Hatoff, Sean Dexter, and Denise Heick

---

[8] Appendix G in the Draft CER- Volume I presents the stability analysis of a future enlarged dam to store 386,000 acre-feet. Considering that the SFPUC does not reasonably foresee the need for a larger dam beyond one that restores the reservoir historical capacity, the stability analysis for the enlarged dam is not needed in this Final CER, and is therefore removed.

- Cost estimates and schedule: Roy Watts, David Hughes, and John Roadifer.

Mike Forrest managed the overall engineering effort, coordinated with other project elements, and conducted technical review of this document. Noel Wong provided project management and oversight for project development and implementation plans.

Independent technical reviews were provided by SFPUC CTAP members Eric Kollgaard, I.M. Idriss, Clarence Allen, Alan O'Neill, and Jack Cassidy.

KEY POINTS

- Calaveras Dam was first completed in 1925, primarily as a hydraulic fill dam. The upstream and downstream shells of the dam were buttressed with rockfill in 1974. The dam is about 210 feet high with a crest length of about 1200 feet.
- The maximum reservoir water level is currently restricted from 756.2 feet (96,850 acre-feet) to about elevation 705 feet (38,100 acre-feet) by DSOD due to concern about the stability of the dam under seismic loading.
- The spillway, which is located at the left abutment, consists of an approach channel with an ungated crest and a concrete-lined trapezoidal chute terminating in a stilling basin that discharges into Calaveras Creek.
- The outlet works include an intake tower (77-foot high)/vertical shaft (146-foot deep) and a 72-inch diameter steel outlet pipe grouted within an 8-foot diameter outlet tunnel.
- A major renovation of the intake tower was completed in 1992.

2.1 GENERAL

As shown on Figure 2-1, the existing project facilities consist of Calaveras Dam, a spillway, outlet works, and conveyance facilities to the Sunol Valley Water Treatment Plant (SVWTP). Calaveras Dam impounds water from several creeks, including Calaveras Creek, Arroyo Hondo and diversion through a tunnel from Alameda Creek. The dam is located on Calaveras Creek in the Diablo Mountain Range in Alameda County, California approximately 12 miles south of the city of Pleasanton. The reservoir is situated in both Alameda and Santa Clara Counties. The reservoir plan, which includes reservoir area and capacity curves are shown on Figure 2-2.

The description of Calaveras Dam and appurtenant works is summarized in Table 2-1. A brief description of the dam, spillway, and outlet works including conveyance facilities is presented below.

2.2 DAM

The dam is about 210 feet high above the downstream toe and has a crest length of about 1,200 feet. Initial construction of the dam started in 1913 using hydraulic filling methods. Construction continued until March 1918, by which point the dam had reached about elevation 764 feet. On March 24, 1918, a very large slope failure occurred in the upstream direction, knocking over the intake tower and transporting dam material over 600 feet upstream of the original centerline. Reconstruction of the dam started in 1923 and was completed in 1925 to an elevation of 779 feet. A limited amount of the failed dam was excavated leaving large depths of failed dam material in place within the upstream shell. The reconstructed embankment consisted of weak rockfill shells and a rolled clay fill above a zone of hydraulic fill.

Following a stability reevaluation by Wahler and Associates in the early 1970's, the upstream and downstream shells were buttressed with rockfill produced from an on-site quarry in 1974. The existing dam site plan and section are shown on Figure 2-3. Because of the type of dam construction and the proximity of the existing dam and reservoir to the Calaveras fault, strong ground motions generated during a large earthquake on the fault could impact the stability of the existing dam (DSOD, 2002). The reservoir water level has been restricted by DSOD since December 2001. Currently, the reservoir water level is restricted to about elevation 705 feet (38,100 acre-feet).

2.3 SPILLWAY

The spillway is located immediately to the west of the dam on the left abutment. The spillway consists of an approach channel with an ungated crest (elevation 756.2 feet) and a concrete-lined trapezoidal chute terminating in a stilling basin. The stilling basin discharges into Calaveras Creek approximately 800 feet downstream from the dam.

The spillway is 155 feet long at its crest and narrows to concrete-lined spillway chute, 19.8 feet in width. The chute widens to 100 feet at the stilling basin. The spillway is approximately 1,467 feet long from the crest to the downstream end of stilling basin. The stilling basin invert is at about elevation 566 feet. Refer to Table 2-1 for information on the spillway.

2.4 OUTLET WORKS

2.4.1 Description

The outlet works include an intake tower/vertical shaft and an outlet tunnel. The tower and vertical shaft consist of a reinforced concrete free-standing tower from approximate elevation 740 feet to 817 feet and a reinforced concrete lined vertical shaft excavated in rock down to an elevation of 594 feet. A total of four intakes (three adits and the drain outlet, see Table 2-1) connect to a vertical 60-inch diameter steel riser located within the tower/shaft. The steel riser connects with a 72-inch-diameter, 1,006-foot-long steel outlet pipe grouted within an 8-foot tunnel.

The 72-inch diameter pipe continues 170 feet from the downstream portal to a bifurcation. One leg continues to a 72-inch fixed cone valve that discharges to the spillway stilling basin. The other leg connects to a 44-inch diameter conveyance pipeline that delivers water 4.1 miles from Calaveras Reservoir to the SVWTP (Figure 2-1).

2.4.2 Renovations

The tower structure and outlet tunnel were originally completed and placed in service in 1925. Major renovations were completed in 1992, which include:

- Installation of a new steel riser within the tower.
- Installation of new piping from the reservoir and new valves on Adits Nos. 1, 2 and 3. The downstream valves are equipped for electrical operation from push button stations at either the valve level or from the top of the tower. Adits Nos. 2 and 3 include an array of drum type fish screens to protect fish from entrainment.
- Refurbishment of the downstream drain valve. (No work was undertaken on the upstream guard valve.)

- Installation of a 72-inch outlet pipe from the tower to connect to the 72-inch fixed cone valve and 44-inch conveyance pipeline. The remainder of the original 8-foot diameter outlet tunnel was grouted, encasing the new outlet pipe.
- Installation of a new system of ladders and platforms within the tower for accessing the valves.
- Construction of a new tower roof.

Table 2-1
Description of Calaveras Dam and Appurtenant Works

Owner	City and County of San Francisco
Stream	Calaveras and Arroyo Hondo Creeks
Location	Approximately 1 mile upstream from junction of Calaveras and Alameda Creeks. Part in Alameda and part in Santa Clara County.
Purpose	Storage for municipal and domestic use
Drainage Area	98.4 square miles (Calaveras/Arroyo Hondo basin) 35 square miles (Alameda Creek basin at diversion point)
Constructed	Construction started 1913 Reconstruction completed 1925 Stilling basin reconstruction 1940
Mean Annual Precipitation	28 inches
Probable Maximum Flood Peak Inflow*	49,521 cfs
Probable Maximum Storm	72-hour duration, 30.8 inches rainfall
Reservoir Pool Elevations**	
Streambed	546.2 ft.
Current Restricted Pool	705.45 ft.
Minimum Pool (dead pool)	600.6 ft.
At Spillway Crest (pre-DSOD restriction)	756.2 ft.
Probable Maximum Flood Pool	776.8 ft.
Reservoir Areas	
At Spillway Crest	1,435 acres
Probable Maximum Flood Pool	approximately 1,600 acres
Reservoir Storage	
At Spillway Crest	96,850 ac-ft (includes sediment)
Probable Maximum Flood Pool	approximately 135,000 ac-ft (not considering sediment)
Length of Reservoir	3.2 miles

---

*Probable Maximum Flood (PMF) parameters reflect calculations performed by URS in 2004. Refer to Section 3.5.

**Elevations are in USGS Datum. Subtract 3.636 feet to convert to San Francisco Water Department (SFWD) datum also referred to as Crystal Springs Datum.

Table 2-1 (continued)
Description of Calaveras Dam and Appurtenant Works

Dam	
Type	Earthfill, part hydraulic sluiced, clay core
Elevation-Top of Dam	778.6 ft. (low point on crest)
Freeboard-Spillway Crest to Top of Dam	22.4 ft.
Structural Height, foundation to dam crest	230 ft.
Height, d/s toe to dam crest	210 ft.
Side Slopes	Upstream: 3H:1V and 5H:1V Downstream: 2-$^3/_4$H:1V average
Length of Crest	1,200 ft.
Base Width	1,510 ft.
Crest Width	80 ft.
Total Volume of Embankment	3,461,000 cy
Freeboard above Probable Maximum Flood Pool	1.8 ft.
Spillway	
Type	Trapezoidal-concrete lined-ungated
Location	Left abutment of dam
Crest Elevation	756.2 ft.
Crest Length	155.12 ft.
Spillway Length (Includes Stilling Basin)	1,466.7 ft.
Outlet Works	
Type	Concrete tower interior diameter 12-feet. Piping rehabilitated in 1991-1992 with four intakes, 0.5-inch thick, 60-inch diameter vertical riser (standpipe)
Location	Left side of dam
Elevation of Intakes/Intake Valve Description	
Drain, El. 602.21 feet	Two 30-inch diameter manually operated gates valves in series
Adit No. 1, Centerline El. 663.55 feet	Two 48-inch diameter knife gate valves in series
Adit No. 2, Centerline El. 699.13 feet	Two 48-inch diameter knife gate valves in series
Adit No. 3, Centerline El. 727.19 feet	Single 60-inch diameter knife gate valve
Conduit	0.5-inch thick 72-inch diameter steel pipe from intake tower to bifurcation 1,176-feet downstream
Tunnel Length	1,006 feet to outlet portal (170 feet upstream of bifurcation)
Tunnel Grade	0.0060
Total Discharge Capacity, Conduit:	
Reservoir Elevation at Spillway Crest	1000-1100 cfs using Fixed Cone Valve
Bifurcation	1. 72-inch diameter leg conveys stream releases approximately 170 feet downstream to 72-inch diameter fixed cone valve, 2. Other leg reduces to 44-inch diameter pipeline and continues approximately 20,500 feet to SVWTP.

KEY POINTS

- The design criteria for the Calaveras Dam Replacement Project provide for a robust design that can accommodate Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE) loading conditions.
- The downstream extent of the replacement dam site is constrained by a large landslide on the right abutment (adjacent to an existing quarry) and the upstream extent is limited by the existing dam that will function as a cofferdam during construction.
- The dam layout is located to avoid active and conditionally active faults.
- Minimum factors of safety for static stability are based on U.S. Army Corps of Engineers guidelines.
- The acceptability of calculated seismically-induced embankment deformations is based on the location of the sliding mass compared to critical zone dimensions such as filter and drain thicknesses.
- Design of the dam will not preclude the potential for reservoir enlargement by future generations.
- The Probable Maximum Flood inflow is the design flood, and was routed through the spillway to determine the required embankment dam freeboard.
- For construction, the existing dam can be used as a cofferdam, and together with the outlet works, would provide sufficient storage and bypass capacity for protection against a 100-year flood event.

3.1 GENERAL

This section discusses the fundamental design criteria that control the project layout: (1) performance objectives, (2) site constraints, (3) reservoir operations, (4) stability, and (5) seismic performance requirements. These criteria were developed early in the conceptual engineering phase and are presented in the Technical Memorandum, Alternatives Evaluation and General Design Criteria, Dam and Appurtenant Works (URS, 2004a). The design criteria were reviewed by both the CTAP and DSOD.

3.2 PERFORMANCE OBJECTIVES

The nominal storage capacity will be restored to the condition prior to the DSOD reservoir level restriction of about elevation 705. Accordingly, the maximum spillway elevation will be elevation 756.2.

Calaveras Dam is under the jurisdiction of DSOD. The following performance objectives were incorporated into the conceptual engineering for the replacement dam:

- The freeboard and spillway capacity are designed for an inflow design flood based on the Probable Maximum Precipitation event;
- Outlet releases will be sufficient to meet DSOD emergency reservoir evacuation requirements; and
- The dam and appurtenant works are to remain functional after the design earthquake. This requires that the safety of the dam embankment itself not be impaired by (1) extensive cracking, (2) crest settlement that would impair freeboard, or (3) excessive deformation in critical zones such as filters and drains. It also requires that the outlet works and spillway remain intact and operational.

3.3 SITE CONSTRAINTS

3.3.1 General

The dam site is limited to an area that extends between the quarry on the west side of the valley and the existing dam (Figures 4-4A to 4-4D). The downstream limit at the quarry was selected to reduce the affected length of Calaveras Creek and associated environmental impacts. The downstream limit is also constrained by landslide hazards as discussed in Section 3.3.2. The upstream limit of the dam axis is about 750 feet downstream of the existing dam axis. Dams located at or downstream of this axis location would use a portion of the existing dam as a cofferdam during construction. Dam axes located further upstream would reduce the available section of the existing dam such that a temporary cofferdam upstream of the existing dam would be required. Alternatives requiring a temporary cofferdam upstream of the existing dam were found to have greater environmental impact and cost (URS, 2005g).

The dam design includes the potential of enlargement for future generations. The site was initially evaluated for a maximum reservoir water surface at elevation 900 (URS, 2004a). The estimated reservoir storage at elevation 900 would be about 420,000 acre-feet. This elevation is approximately the maximum that the reservoir water surface could be raised without requiring a saddle dam, which would be located on the active Calaveras Fault (about 2,000 feet west of the dam). URS does not recommend constructing a dam across this active fault. Furthermore, constructing a dam across this fault would involve major DSOD permitting difficulties. For conceptual engineering, the maximum increase in reservoir capacity is reduced to the intake elevation (890 feet) of the Upper Alameda Creek Diversion Dam. The estimated reservoir storage at elevation 890 would be about 386,000 acre-feet.

3.3.2 Landslide Hazards

Quaternary landslides have been identified on the northern and eastern hillsides above Calaveras Creek, downstream of the existing dam. In particular, the area downstream of the right abutment of the existing dam is characterized by several landslides ranging from a few tens of feet in width up to several hundred feet wide and extending from Calaveras Creek to the ridgeline. These landslides are further discussed in Section 4.4.3.

The dam was located to avoid large landslides that cannot be removed economically or removed without major environmental impact. As such, the large landslide on the downstream right abutment across from the existing quarry (Section 4.4.3) limits the downstream extent of the dam site.

3.3.3 Fault Activity and Hazards

Faulting in the vicinity of the dam has been documented over many years by various investigators. The main trace of the active Calaveras Fault is located in the topographic saddle through which Calaveras Road trends, about 2,000 feet west of the dam. The Gully Fault is located in a minor ravine, about 1,000 feet west of the dam, and is considered to be conditionally active as discussed in Section 5. The dam was located to avoid faults that are considered active or conditionally active based on DSOD guidelines (Section 5.1).

Two secondary faults, the Spillway Fault and the Quarry Fault, are located in the immediate vicinity of the dam. The Spillway Fault (Figures 4-4A to 4-4D) is mapped as a north-south trace directly to the west of the existing spillway. The Quarry Fault (Figures 4-4A to 4-4D) is located in the right abutment. The results of investigations of these faults, which are summarized in Section 5, indicate that these faults are inactive. Being inactive, these faults do not pose site constraints from fault displacement or ground motions.

3.4 SLOPE STABILITY

Analyses were performed to evaluate the stability of the replacement dam under various loading conditions as described in Appendix D. The minimum sliding factors of safety for the various loading conditions are listed in Table 3-1 (USACE, 1970).

Table 3-1
Loading Conditions and Stability Criteria

Loading Condition	Slope	Minimum Sliding Safety Factor
End of Construction	Both	1.3
Emergency Rapid Reservoir Drawdown	Upstream	1.2
Operational Reservoir Drawdown	Upstream	1.4
Steady Seepage with Partial Pool	Upstream	1.5
Steady Seepage with Maximum Storage Pool	Downstream	1.5

Seismically induced displacement analyses were performed as described in Appendix D. Seismic ground motions parameters used in the analysis are described in Section 6. The acceptability of the calculated deformations is based on the location of the sliding mass within the embankment (deformation pattern) and will be compared to critical zone dimensions such as filter and drain thicknesses.

3.5 DESIGN FLOOD AND FREEBOARD

3.5.1 Design Storm and Flood

Design flood criteria for the proposed spillway design was developed based on DSOD guidelines. According to these guidelines, reservoir spillways are required to have adequate capacity to pass the Probable Maximum Flood (PMF) event, based on routing an inflow design flood resulting from a Probable Maximum Precipitation (PMP) storm event, while maintaining adequate freeboard on the dam.

Probable Maximum Precipitation Depth

DSOD estimated PMP depths for the Calaveras Reservoir watershed (DSOD, 1979). In its study, DSOD estimated the 72-hour PMP depth for the Calaveras Reservoir watershed as 28.4 inches based on guidelines provided in Hydrometeorological Report No. 36 (U.S. Weather Bureau, 1961 and 1969).

For this study, the 72-hour PMP depth for Calaveras Reservoir watershed was estimated based on the current guidelines presented in Hydrometeorological Report No. 58 (U.S. Department of Commerce, 1999). Using these updated HMR guidelines, the 72-hour duration PMP depth is estimated to be 30.8 inches.

Probable Maximum Flood Hydrograph

A PMF inflow hydrograph for Calaveras Reservoir was calculated using the U.S. Army Corps of Engineer's HEC-HMS model (May 2003) and the updated PMP depth. Hydrologic input data for the HEC-HMS model, including drainage area (98.4 square miles) and SCS Curve Number (CN=65), were estimated from USGS topographic maps and land cover (USGS, 1992) and hydrologic soil group (NRCS, 2003) GIS data layers.

To assure consistency with the August 1979 DSOD analysis, the HEC-HMS model was calibrated to reproduce the same PMF inflow hydrograph derived by DSOD for a PMP of 28.4 inches. The calibrated HEC-HMS model was then used to derive a new PMF inflow hydrograph for the updated PMP value of 30.8 inches. Figure 3-1 shows the new PMF inflow hydrograph and the rainfall hyetograph for the updated PMP. The maximum PMF inflow was calculated to be 49,521 cfs, which includes 48,791 cfs calculated from the natural watershed and 730 cfs additional inflow from the Alameda Creek Diversion.

3.5.2 Freeboard

Freeboard as defined by DSOD is the vertical distance from the spillway crest to the dam crest. Residual freeboard is the distance from the maximum reservoir stage for spillway design flood and the dam crest (DSOD, 1993).

The objective of freeboard is to prevent overtopping of the dam under extreme circumstances given uncertainties in the calculations. Freeboard for earthfill dams (such as Calaveras) is required to be the greater of the following:

- Minimum of 10 feet plus 5 percent of the dam hydraulic height above 100 feet, or
- PMF surcharge plus wind wave runup and reservoir setup from maximum wind storm event plus 1.5-foot residual freeboard.

PMF Surcharge

The inflow design flood hydrograph (Figure 3-1) discussed in Section 3.5.1 was routed through the reservoir using the HEC-HMS model to estimate the maximum PMF surcharge for the spillway for the replacement dam. The reservoir stage-storage curve used for the routing analysis is the same as shown on Figure 2-2. Using the open channel spillway discharge curve shown in Figure 3-2 (developed for an ogee type spillway with a length of 120 feet), the PMF surcharge at the spillway was calculated to be 18.6 feet. (Similar analysis of the existing spillway shows the PMF surcharge is 20.6 feet with the revised PMF inflow.)

Wind Wave Runup and Setup

Wind wave runup and wind setup analyses were performed to estimate freeboard requirements for the reservoir. Wind wave runup is defined as the vertical height above still-water level to which water from an incident wave will run up the face of the dam. Wind setup is a general tilting of the water surface due to shear stress caused by winds. To estimate the wave runup and setup for the reservoir, the following design parameters were used:

- Spillway elevation of 756.2 feet.
- Fetch length of 0.97 miles. This length was calculated in accordance with procedures outlined in "Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams" (USBR, 1992).
- A design wind velocity of 70 miles per hour as a "fastest mile of record" (UBC, 1997).
- Reservoir embankment slope of 2.5H:1V with riprap armor in place.

Based on the above design conditions, wave runup plus setup values for the reservoir was estimated to be 1.5 feet. Therefore,

Minimum Design Freeboard = PMF surcharge + 1.5 feet + 1.5 feet.
= 18.6 feet + 3.0 feet
= 21.6 feet.

Therefore, the minimum dam crest elevation would be elevation 777.8 feet (756.2 + 21.6 feet) for a new spillway having an ogee type crest with a length of 120 feet. For conceptual engineering, the crest of the dam was set at 778.0 feet.

3.6 RESERVOIR EVACUATION REQUIREMENTS

The DSOD requires that dams be provided with outlet facilities with sufficient capacity to evacuate the reservoir quickly, should an unsafe condition develop at the dam. DSOD "guidelines" for emergency drawdown rate for large reservoirs are based on having the capability to:

- Lower the reservoir elevation by an amount equal to ten percent of the hydraulic head behind the dam in ten days. Hydraulic head is defined as the elevation difference between the normal maximum water surface and deadpool surface.
- Evacuate the reservoir to deadpool elevation within 120 days.

The existing dam has a hydraulic head of 147 feet (elevation 756.2 - 609.1 feet). Approximately 19,800 acre-feet are stored in the top 14.7 feet, (10 percent of the head). It would require an average release rate of 996 cfs to evacuate this quantity of water over a ten-day period. With a 72-inch outlet, the velocity is 35.2 feet per second (ft/sec). The existing outlet system as rehabilitated in 1991-1992 was designed to meet this release rate. The replacement dam would restore the reservoir to its original storage capacity. As such, there would be no difference in the emergency drawdown requirement. As discussed in Section 7.4, from an operational and maintenance perspective, a new intake tower is preferred, even though the existing structure can achieve DSOD evacuation requirements.

For the replacement dam, the existing outlet conduit would be extended and the fixed cone discharge valve would be moved approximately 500 feet downstream. While this would result in an increase in head loss through the outlet conduit, it is largely offset by an increase in head due to the slope in the stream channel. Discharge from the fixed cone valve will be directed to the stilling basin to avoid erosion of the existing pipeline and the toe of the landslide downstream of the new dam embankment. Design criteria will assess the location of a guard valve in the outlet works system.

3.7 RESERVOIR OPERATIONS

3.7.1 Normal Operations

The SFPUC has historically operated Calaveras Reservoir to meet the following objectives:

- Maximize storage within the reservoir to meet potential drought and water supply needs
- Maximize conservation of runoff on a long-term basis
- Meet short-term water supply operational requirements.

Prior to 2002 in normal or wet years, the reservoir would normally be allowed to fill by the end of the rainy season and drawn down 15,000 to 20,000 acre-feet by early winter in order to capture winter runoff. During a drought or water supply emergency, the reservoir would be drawn down to meet SFPUC water supply needs.

Since December 2001, the reservoir has been operated with a restricted capacity as established with DSOD. Normal restricted storage is limited to about elevation 705 feet (approximately 38,100 acre-feet not considering sediment). Following periods of heavy inflow, reservoir storage rises temporarily while the SFPUC utilizes "best efforts" to lower the level while making beneficial use of the water, and, if necessary, discharging excess inflow to Calaveras Creek. The SFPUC has also been maintaining a minimum pool elevation of 690.0 (approximately 25,700 acre-feet not considering sediment[9]) in accordance with a 1991 letter sent to the California Department of Fish and Game (CDFG).

For water quality reasons, releases would normally be made through one or both of the upper ports (Adit Nos. 2 and 3); Adit No. 1 and the tunnel inlet port would be kept closed. However, given the current restriction on storage, Adit No. 3 is normally above the water surface and so releases are made through Adit No. 1 and sometimes Adit No. 2. Adits No. 2 and 3 are screened to protect fish; Adit No. 1 and the tunnel (drain) have only debris screens.

In 1997, the SFPUC and CDFG signed a Memorandum of Understanding (MOU) regarding water releases and minimum pool elevations from July through October to improve the cold water fishery resource downstream of Calaveras Dam. The requirement to release up to 6,300 acre-feet per year of water for the enhancement of fisheries and other natural resources of Calaveras and Alameda Creeks has not been fully implemented because of the current limitations in storage ordered by DSOD.

The 72-inch diameter fixed cone valve has been used for special fish studies. Releases are also made from this valve to help return the reservoir to the DSOD restricted capacity level during periods of high inflow. The cone valve would be used to its full capacity in an emergency to rapidly draw down the reservoir.

The reservoir operations plan for this project, when constructed, is presented in Appendix B.

3.7.2 Construction Flood

General

The existing dam (modified as required for stability) will serve as the cofferdam for construction of the replacement dam. A portion of the downstream shell of the existing dam will need to be excavated to provide for foundation excavation for the replacement dam and the existing spillway will be demolished as part of construction of the replacement dam. Flood protection during the construction period will be provided by a combination of flood storage capacity behind the cofferdam and releases through the existing outlet works.

Design Storm Events

A flood frequency analysis was completed to evaluate the inflow associated with various recurrence periods for the site. Baseline data included daily flows for 58 years from the following gages:

- USGS 11173500, Calaveras Creek Near Sunol CA (Calaveras Dam Site), 98.7 square miles, years 1898-1916
- USGS 11173200, Arroyo Hondo Near San Jose, CA (Tributary to Calaveras Creek), 77.1 square miles, years 1969-1980 and 1994-2001
- USGS 11176400, Arroyo Valley Near Livermore, CA, 130 square miles, years 1963-2001.

---

[9] Based on a bathymetric survey performed by SFPUC in 2000, the actual storage at elevation 690 is estimated to be 22,600 acre-feet due to the accumulation of sediment over the last 80 years.

The Calaveras Creek gage provided 17 years of data prior to the construction of Calaveras Dam. The Arroyo Hondo data provided an additional 21 years of data. The data were adjusted upwards in direct proportion to the area at Arroyo Hondo compared to the area at the dam site. An additional 18 years of data from the Arroyo Valley gage was used following completion of regression analysis based on 21 years of concurrent data with the Arroyo Hondo gage.

Table 3-2 summarizes the range of return frequency flood events that were evaluated for flood potential during construction. Both short-term and long-term events were considered. The short-term event routed the inflow associated with events of various return periods through the outlet works to determine the rise in storage. The routing return periods were selected from yearly maximum 72-hour events. The entire storm event (longer than 72-hours) was routed through the reservoir. The long-term event used for the evaluation was the maximum winter sequence of record.

Table 3-2
Inflow Events

Event	Inflow
10-year event	16,000 acre-feet over 72 hours
25-year event	20,000 acre-feet over 72 hours
100-year event	28,000 acre-feet over 72 hours
Max historical sequence	118,000 acre-feet over the period January 1 to March 31, 1983, including 54,000 acre-feet in March 1983 alone.

Existing Outlet Capacity

As previously described in Section 2.3, the existing outlet system consists of three horizontal adits and a low level tunnel (drain) connecting to a vertical tower connecting to 6-foot diameter outlet conduit. Discharge capacity through the outlet system (see Figure 3-3) is estimated based on the 30-inch diameter valve at elevation 602.59 feet (low level tunnel inlet), the 48-inch diameter valves at elevations 663.55 and 699.3 feet (Adits Nos. 1 and 2) and the 60-inch diameter valve at elevation 727.19 feet (Adit No. 3) in the intake tower. These valves were assumed to be fully open and the downstream 72-inch fixed cone valve was also assumed to be fully open.

Flood Routing

Two starting cases were assumed at the start of the flooding sequences considered. Case 1 is based on the lowest normal operating elevation in the reservoir at present (elevation 693.45). Case 2 is based on the current restricted upper operating limit of the reservoir. A summary of results of these flood routing analyses is presented in Table 3-3.

Table 3-3
Construction Flood Routing Results

Event	Case 1 - Starting Elevation 693.45		Case 2 - Starting Elevation 705.45	
	Delta Storage (AF)	Max. Elevation	Delta Storage (AF)	Max. Elevation
10-Year	14,950	711.6	13,707	720.0
25-Year	23,974	720.8	22,634	728.2
100-Year	35,933	731.3	34,683	737.6
Long-Term Event	30,196	726.5	25,188	730.4

Table 3-3 indicates the height that must be maintained for the existing dam to serve as a cofferdam to provide the various levels of downstream flood protection during construction of the new replacement dam. Analyses show that retaining a portion of the existing dam able to safely store water to approximately elevation 732 feet would provide protection for a 100-year storm event if the reservoir starts out at its current minimum level (Table 3-3, Case 1). Retaining the existing dam such that it is able to safely store water on a temporary basis to approximately elevation 738 feet would provide protection for a 100-year storm event if the reservoir starts out at its current maximum elevation (Table 3-3, Case 2).

KEY POINTS

- The site is suitable for construction of an earthfill dam and sufficient materials are available on site for the main zones of the dam.
- A geotechnical investigation program including field explorations and laboratory testing was conducted to investigate foundation conditions at the dam and availability of materials in borrow areas.
- The left abutment is highly to intensely fractured Temblor Sandstone and the right abutment and the channel bottom is a mixture of serpentinite, siliceous schist, blueschist, sheared shale, and other rocks of the Franciscan Complex locally overlain by colluvium, landslide deposits, alluvium, and fill.
- The high hydraulic conductivities in the upper part of the Temblor Sandstone indicate the need for a seepage control system that extends to depths of about 100 feet below the ground surface in the left abutment.
- Curtain grouting would be needed to reduce seepage in the right abutment.
- The landslide that is within the dam foundation area is approximately 300 to 400 feet wide and over 1,200 feet long and will be removed from the dam footprint as part of the foundation excavation.
- Embankment shell materials can be obtained from the Temblor Sandstone borrow area in the dam site. Core materials can be obtained from a borrow area at the upstream end of the reservoir.
- Riprap can be produced from an existing on-site hard rock quarry and salvaged from the existing dam. Riprap bedding could be produced from the existing rock quarry or be imported.
- Filter and drain materials would be imported or may be processed from alluvial fan deposits at the upstream end of the reservoir.

4.1 REGIONAL GEOLOGY

Calaveras Dam and Reservoir are located in the geologically active eastern San Francisco Bay region, an area characterized by a few well-defined active faults, including the Calaveras, Hayward, Greenville, and Concord faults (Figure 4-1). The reservoir inundates Calaveras Valley, which was formed, in part, as a result of movement on the Calaveras fault over geologic time.

Calaveras Dam and Reservoir lie within the western part of the Diablo Range (Figure 4-1), which rises to elevations of more than 3,000 feet. In a regional sense, the Diablo Range lies generally east of the Calaveras fault and consists of Coast Range ophiolite and Franciscan Complex rocks locally overlain by uplifted marine and non-marine Quaternary sediments. Across the Calaveras fault, rocks of the Eastern Belt Franciscan Complex are juxtaposed on the east against Cretaceous sedimentary rocks of the Berryessa Formation and younger Tertiary rocks on the west. Quaternary and Tertiary rocks and sediments underlie the Santa Clara Valley and the East Bay Hills (Figure 4-1) located west of the Calaveras fault.

4.2 CALAVERAS FAULT

The Calaveras fault, located about 2,000 feet west of the dam site, is the most significant seismic source to the project in terms of strong ground shaking. The 130-km (80-mile) long Calaveras fault traverses the Hollister Plain and the Diablo Range east of the Santa Clara Valley (Figure 4-2), and is a major structural boundary between the Diablo Range and the San Francisco Bay structural depression (Page, 1982). The Calaveras fault exhibits prominent geomorphic expression along its entire active length of 130 km (80 miles), and has generated small and moderate earthquakes during the past two hundred years of recorded history. Based on structural relations with other major faults, contemporary seismicity, rate of present-day creep and geodetic deformation, and geomorphic expression, the Calaveras fault is interpreted to consist of three primary sections as shown on Figure 4-2 (Kelson 2001; WGCEP, 1999, 2003). These sections may or may not reflect actual earthquake rupture segments, and are defined as the :

- Northern Calaveras fault (from Danville to Calaveras Reservoir)
- Central Calaveras fault (from Calaveras Reservoir to San Felipe Lake)
- Southern Calaveras (from San Felipe Lake to the Paicines fault south of Hollister)

Calaveras Dam and Reservoir are located near the intersection of the northern and central Calaveras faults (Figure 4-2). These two faults are separated by a distinct right-releasing bend in the overall fault trace.

The structural and behavioral differences between the northern and central Calaveras fault have led most workers to postulate the presence of a major segmentation point in the vicinity of Calaveras Reservoir (Oppenheimer and Lindh, 1992; Kelson, 2001; WGCEP, 1999, 2003). The reservoir inundates Calaveras Valley, which is a broad, flat-floored valley within the Diablo Range (Figure 4-3). This valley coincides with the intersection between the Calaveras fault and Mission seismicity trend and with a releasing bend in the Calaveras fault (WLA/URS, 2005). The bend along the Calaveras fault near Calaveras Reservoir is referred to as the “Calaveras Valley releasing bend”. It is interpreted that the complex deformational pattern in this releasing bend probably arrests rupture propagation from the northern Calaveras fault on the north, or the central Calaveras fault on the south. A comprehensive description of the Calaveras fault is contained in WLA/URS (2005).

Secondary faults in the vicinity of Calaveras Dam include the Quarry, Spillway and Gully faults (Figures 4-4A through 4-4D). Investigations of these faults are discussed in Section 5.

4.3 GEOTECHNICAL INVESTIGATIONS

A geotechnical investigation and testing program was completed at the project site to collect data on the site geology and characterize the soil, rock and groundwater conditions of the dam foundation, borrow areas, reservoir rim and conveyance pipeline between the existing Calaveras Dam and the Sunol Water Treatment Plant. The geotechnical investigations included the following tasks:

- Reviewing relevant available geologic and geotechnical information
- Reviewing and interpreting available aerial photos
- Field geologic mapping and preparing geologic maps

- Excavating fault trenches (results are presented in Section 5)
- Conducting seismic refraction surveys
- Drilling bucket auger borings
- Excavating test pits
- Drilling rock core borings and conducting packer tests
- Performing downhole acoustic televiewer and downhole seismic velocity measurements
- Laboratory testing of soil and rock.

The results of the URS field investigations are contained in the Geotechnical Data Report (URS, 2005a). A Geotechnical Interpretive Report (URS, 2005b) contains URS' interpretations of the data obtained during the field investigations. The following sections summarize the results of the URS field investigations and interpretations for the dam site. The logs of borings and test pits referenced in the following sections can be found in the Geotechnical Data Report. Fault trench logs can be found in a report titled Evaluation of Fault Rupture Potential at Calaveras Dam (Task 6.2) (WLA/URS, 2005). The rock cores from URS' investigation are currently stored in freight containers at the west end of the crest of the dam.

4.4 DAM FOUNDATION

The dam foundation downstream of the existing dam presents complex geotechnical conditions. Due to the proximity to the Calaveras Fault Zone, the rocks in the project area have been repeatedly exposed to shearing and other tectonic forces.

In the channel downstream of the existing dam, there are alluvium deposits up to 20 feet thick. Colluvium deposits are encountered primarily on the right abutment. Construction of the existing dam resulted in removal of much of the colluvium on the left abutment. The thickness of the colluvium ranges from less than a foot on ridges to more than 10 feet in filled drainages.

The left abutment is highly to intensely fractured[10] Temblor Sandstone and the right abutment and the channel bottom is a mixture of serpentinite, siliceous schist, blueschist, sheared shale, and other rocks of the Franciscan Complex locally overlain by colluvium, landslide deposits, alluvium, and fill. The unconformable contact between the Temblor Sandstone and the Franciscan Complex, shown on Figures 4-4A through 4-4D, dips to the northwest at approximately 20 to 25 degrees.

4.4.1 Temblor Sandstone

The Temblor Sandstone, which includes occasional thin shale and conglomerate interbeds, is generally very weak to moderately strong[11] until at least 100 feet below the ground surface. The unconfined compression strengths of the Temblor Sandstone versus degree of weathering are summarized in Table 4-1.

---

[10] The definitions for degree of fracturing are in the Geotechnical Data Report (URS, 2005a).

[11] The definitions for rock strength are in the Geotechnical Data Report (URS, 2005a).

Table 4-1
Unconfined Compressive Strengths (UCS) of Temblor Sandstone

Weathering Degree	Number of Tests	UCS Range (psi)	UCS Mean (psi)
Highly to Mod. Weathered & Mod. Weathered	7	540-2600	1390
Mod. to Slightly Weathered & Slightly Weathered	23	1400-6400[1]	3180

[1] Discarded low values of 270 and 950 psi

The Temblor Sandstone becomes predominantly slightly weathered[12] at an approximate depth of 20 feet below the surface in core boring CB-1, drilled in the left abutment. However, in CB-2, also drilled in the left abutment, moderately weathered rock was encountered at a depth of 38 feet and slightly weathered conditions do not occur until 94 feet below the surface. Locations of the core borings and other exploration points are shown on Figures 4-4A through 4-4D.

The borings drilled in the Temblor Sandstone encountered open joints with apertures as wide as 0.5 inches and observation of outcrops revealed open joints up to 6 inches in width. Gypsum, which is a soluble mineral, was observed in boring CB-26 (located on the north side of Observation Hill), mostly as fracture filling. In general, results of the packer testing indicate the hydraulic conductivities in the upper 60 to 100 feet of the Temblor Sandstone are high, and range from 100 to 400 lugeons. The hydraulic conductivities decreased below this depth. The high hydraulic conductivities in the upper part of the Temblor Sandstone indicates the need for a seepage control system that extends to depths of about 100 feet below the ground surface in the left abutment.

4.4.2 Franciscan Complex

East of the Temblor Sandstone contact in the dam foundation, various lithologies of the Franciscan Complex are represented. Serpentinite is exposed at the ground surface just upstream of the existing dam, in the vicinity of the intake tower. Beneath the channel downstream of the existing dam, and on the right abutment, the bedrock lithology is mélange with various proportions of shale, siliceous schist, graywacke sandstone, serpentinite, and blueschist. The mélange shale matrix and the serpentinite are very weak to weak rocks. Blocks of graywacke are usually moderately strong to strong. The blueschist, unless it is mixed with sheared serpentinite or shale mélange, is also moderately strong to strong.

The unconfined compressive strengths of the Franciscan rocks vary according to the lithological type, as summarized in Table 4-2. Also, as shown in Table 4-2, the strengths within a rock type vary widely and depend on weathering, fractures, foliation, and the amount of mélange shale and serpentinite within the rock.

---

[12] The definition for degree of weathering of rock are in the Geotechnical Data Report (URS, 2005a).

Table 4-2
Unconfined Compressive Strengths (UCS) of Franciscan Rocks

Rock Type	Number of Tests	UCS Range (psi)	UCS Mean (psi)
mélange shale	11	140-1300[1]	620
serpentinite	9	220-3200	1040
siliceous schist[3]	6	350-3400[2]	1400
graywacke	13	1900-11,500	6320
mélange blueschist	2	850-1100	N/A
blueschist	7	1800-11,500	7580

[1] Discarded high value of 2940 psi
[2] Discarded high value of 8750 psi
[3] Often serpentinized

The unconfined compressive strength data are biased to the high side because only core samples that were suitable for testing were selected, which are the better quality samples.

The Franciscan Complex bedrock observed in borings CB-3 through CB-7, CB-19 through CB-22, and CB-24, drilled in the channel bottom and right abutment (Figures 4-4A through 4-4D), varies significantly in lithology and degree of weathering. Discontinuous, moderately strong to strong blueschist, siliceous schist, and graywacke occur within shale mélange in borings drilled in the Franciscan Complex. Brecciated zones were also encountered in the borings (e.g., in boring CB-6 between 45 feet and 51 feet below the ground surface).

Estimation of the percentage of strong blocks of blueschist, siliceous schist, and graywacke within the shale matrix encountered in the core borings indicates that, overall, these blocks constitute about 35 percent of the rock mass, and about 30 percent of the rock mass in the dam foundation. The mélange shale matrix and the serpentinite, which are weak to very weak rocks, constitute about 70 percent of the Franciscan Complex rock mass in the dam foundation. The proportions indicated in the vertical dimension can be expected to be approximately representative of the lateral exposure of this formation in the foundation.

Results of the packer testing completed in the Franciscan Complex indicate the rock mass has a relatively low overall hydraulic conductivity. With a few exceptions, the results of the packer testing indicated values of less than 40 lugeons and mostly less than 10 lugeons, and do not show a trend with depth. The exception was in boring CB-5 where high water takes of 480 and 340 lugeons were measured at depths of 42 to 53 feet and 70 to 81 feet, respectively. Curtain grouting would be needed to reduce seepage in the right abutment.

4.4.3 Landslides

Landslides in the proposed dam foundation area occur on the right abutment. These landslides are largely a result of the unstable nature of the Franciscan Complex rocks and the colluvial soils derived from them. Most of the landslides mapped on the right abutment are relatively small features, typically less than 200 feet wide and 400 feet long. A large landslide exists on the downstream right abutment, across from Hill 1000 (the existing quarry), and likely involves millions of cubic yards of material. This landslide is partially shown on Figure 4-4B. The landslide that is within the dam foundation area is approximately 300 to 400 feet wide and over 1,200 feet long (Figure 4-4D) and will be removed from the dam footprint as part of the foundation excavation. The approximate thickness of landslide material observed in the core and bucket auger borings drilled within the landslide (CB-21, and BA-8, -9, and -11) ranges from 26 to 64 feet.

4.5 BORROW AREAS

The geotechnical investigation was also directed to evaluate potential borrow material quality and quantity. The results of the investigation show that there are earthfill and rockfill material sources on site. Embankment shell materials can be obtained from the Temblor Sandstone (Borrow Areas A and B1) from the western side of the site. A plan showing the limits of the borrow areas is shown on Figure 4-5. Rockfill and riprap materials consisting of the Franciscan blueschist and greywacke can be obtained in the existing quarry (Borrow Area B2).

Limited clayey soils for an earthfill dam core can be obtained from onsite colluvium. Due to limited depths of soils in the colluvial borrow areas (Borrow Areas C and D), large areas would be required to obtain useful quantities. Clayey soils for the core can be obtained from the alluvium at the upstream end of the reservoir (Borrow Area E).

The portions of the existing dam excavated during construction could also be a source of embankment fill materials. Riprap from the existing dam could also be used. Due the variability of the mélange shale and its low strength, this material is not considered to be a potential source of embankment fill materials.

The estimated in-situ quantities of materials available from each of the borrow areas is presented in Table 4-3.

Table 4-3
Estimated In-Situ Borrow Area Quantities

Borrow Area	Material Type	Total Area (Acres)	Estimated Thickness (Feet)[1]	Estimated In-Situ Quantities (CY)
Area A - Observation Hill	Temblor Sandstone	20	325	>7,000,000
Area B1 - Hill 1000	Temblor Sandstone	23	260	1,600,000
Area B2 - Hill 1000	Blueschist/ Graywacke	8	280	2,200,000
Area C1 - North of Observation Hill	Colluvium	8	1 to 20	140,000
Area C2 - North of Observation Hill	Colluvium	>50	(Note 2)	(Note 2)
Area D - West of Observation Hill	Colluvium	28	3 to 10	160,000
Area E - South of Reservoir	Alluvium	85	>15	>2,000,000

Notes:
1. Thickness for A, B1, and B2 are maximum thicknesses. For Areas C1, D and E, thicknesses are the range over the entire area.
2. No thickness and quantity estimates for C2, as this area was not explored for Conceptual Engineering.

4.5.1 Borrow Area A

Borrow Area A, on Observation Hill, consists of very weak to moderately strong Temblor Sandstone. The underlying serpentinite is not considered to be a potential borrow source.

As observed in borings, the Temblor Sandstone is generally highly fractured and the weathering profile is correspondingly deep (more than 150 feet in CB-16 and CB-26, and 45 feet in CB-15, to slightly weathered rock), especially along open joints. Based on the results of point load, unconfined compression, and abrasion tests, most of the Temblor Sandstone is expected to break down under excavation, handling, and compaction and would provide earthfill for shell material, rather than rockfill. Most of the Temblor Sandstone material should be rippable. However, it may be more economical to drill and blast for borrow operations. Groundwater was not encountered in the borings drilled in Borrow Area A.

4.5.2 Borrow Area B

Borrow Area B has been subdivided into a Temblor Sandstone source (Borrow Area B1 on Figure 4-5) and a blueschist/greywacke (Borrow Area B2 on Figure 4-5).

The Temblor Sandstone, as observed in boring CB-18 in Area B1 is weak to moderately strong, similar to that in Borrow Area A. Except for occasional zones, the rock mass becomes less fractured below a depth of approximately 50 feet. However, based on the results of point load testing, most of this material is expected to break down under compaction and would be used as shell material in an earthfill dam.

Most of the Temblor Sandstone in Borrow Area B1 should be rippable to the maximum proposed depth. However, the data from the downhole seismic velocity survey in boring CB-18 indicate a P-wave velocity over 8,000 fps below a depth of 63 feet. This would indicate that blasting could be required below that depth. Because localized zones of strongly cemented rock may be present, blasting may be applicable below a depth of about 30 feet, where the sandstone becomes slightly weathered.

The blueschist/graywacke portion of Borrow Area B2 is located northeast of Borrow Area B1, extending from the level of Calaveras Creek at approximate elevation 520 feet up to approximate elevation 760 feet. Blueschist and graywacke are the hardest, strongest rocks encountered in the project area. The unconfined compressive strengths of the blueschist and graywacke tested were as high as 11,500 psi. This material would be used for riprap and possibly riprap bedding. Past quarrying activities in Borrow Area B2 produced the blueschist riprap that was placed on the upstream side of the existing dam in the mid-1970s.

The present quarry walls are nearly vertical. Observation of blueschist outcrops in the existing quarry and rock core from borings CB-25 and CB-25A indicate that most of the rock within the limits of this portion of the borrow area would be useable as hard rockfill. The blueschist and graywacke material is considered unrippable and will need to be systematically drilled and blasted for rock production operations.

4.5.3 Borrow Area C

Borrow Area C, north of Observation Hill, is a potential source of colluvium for earthfill core material. This borrow area was subdivided into two borrow areas: Borrow Area C1 is located in a draw on the north side of Observation Hill and Borrow Area C2 is further to the northeast. Most of the material would be available from the valley where the Spillway Fault trace is shown on Figure 4-4a (Borrow Area C1). The colluvium is much thinner to nonexistent on the ridges that flank this area. The quantity presented in Table 4-3 is from the valley area only.

Observations in fault trenches FT-4 and FT-5, as well as geophysical data from the seismic refraction surveys indicate that the colluvium in the valley reaches a thickness in excess of 20 feet. The readily excavated colluvial soils generally consist of low plasticity to high plasticity clayey soils, with sand and some gravel and cobbles. The laboratory test data indicate fines contents ranging from 40 to 79 percent, which are sufficient for use in an embankment dam core zone. Groundwater was not encountered during excavation of FT-4 and FT-5 in January 2004.

The colluvial soils are fairly consistent, but occasional cobbles and boulders of Temblor Sandstone and Claremont Shale were observed in FT-4 and FT-5, and as surficial float. In addition, the clayey colluvium can abruptly transition into residual soil overlying bedrock, which would produce oversize or granular material unsuitable for use as core fill. Excavation in Borrow Area C would require development of a large area to produce useful quantities of materials because soil thicknesses are limited. Excavation in this borrow area would require a high level of control so that unsuitable materials are not placed in the core fill.

4.5.4 Borrow Area D

Borrow Area D, the portion of Observation Hill west of the Gully Fault, is another potential source for colluvium for earthfill core materials. The source for the clayey colluvium is the underlying Berryessa Formation mudstone. Although a weaker material than the Temblor Sandstone, the Berryessa Formation mudstone is a potential supplementary source of earthfill shell materials.

The readily excavated colluvial soils in Borrow Area D generally consist of low plasticity clayey soils, with sand and some gravel. The laboratory test data indicate fines contents ranging from 17 to 79 percent, which are sufficient for an embankment dam core zone. The thickness of the colluvium varies throughout the borrow area. Based on data from test pits and seismic refraction surveys, soil depths range from nonexistent on ridges to as much as 8 to 10 feet in the saddles and ravines. This variation in thickness could possibly raise issues with material consistency during excavation. As in Borrow Area C, unsuitable oversize or granular material could be produced from the residual soil/weathered bedrock zone if the excavation operation is not closely supervised. Like Borrow Area C, excavation in Borrow Area D would require development of a large area to produce the volumes indicated in Table 4-3 because soil thicknesses are limited.

Groundwater was encountered as shallow as 5 feet (in TP-17), in a ravine where the Gully Fault is projected. Seeps were also observed in various locations during the winter 2004 investigation, as shown on Figure 4-4A. Groundwater control in Borrow Area D will be needed, and if the excavation extends below groundwater, the soils would need to be dried back prior to placement.

4.5.5 Borrow Area E

Borrow Area E, located at the south end of the reservoir, is located in a wide, nearly flat alluvial-filled valley floor. The Calaveras Test Site is located at the east end of Borrow Area E. The Calaveras Test Site Hazardous Waste Evaluation Technical Memorandum (URS, 2004f) shows the extent of residual, chlorinated hydrocarbon impacted soils and groundwater in the test site area. Borrow Area E was configured to avoid this area.

The alluvial soils in Borrow Area E exceed a thickness of 10 to 11 feet, the depth of exploration in test pits TP-7, TP-8, TP-9, and TP-10 (URS, 2005a). The potential borrow material is relatively consistent and generally contains sandy to silty low plasticity clays. Laboratory test data indicate fines contents ranging from 21 percent to 65 percent, which are sufficient for use in a core zone. The in-situ moisture contents ranged from 11 to 19 percent. Compared with an optimum moisture content of 14 to 15 percent, this material would likely require limited in-place moisture conditioning prior to fill placement.

During the winter 2004 investigation, groundwater was not encountered in the test pits to the depth of exploration. Borrow excavations would need to be kept away from the reservoir shoreline to reduce the potential for seepage inflows. The relatively flat terrain of this borrow area and the consistency of the materials should make excavations relatively straightforward. However, transporting the material to the dam site would require construction of haul roads or barging the materials across the reservoir.

4.5.6 Potential Borrow Site for Sand and Gravel

In addition to the clayey soils in Borrow Area E, a reconnaissance indicated the potential for coarse sand and gravel with cobbles and boulders in young alluvial fan deposits in the vicinity of Borrow Area E and extending east and southwards along the active channel and flood plain of Calaveras Creek (URS, 2005b). The gravels in this deposit consist mainly of graywacke derived from the Franciscan Complex with minor chert, greenstone and weaker sandstone from the Great Valley Sequence and Tertiary Sandstone formations found upstream. These gravels are slightly to moderately weathered, strong and appear to be a potential source of aggregate, filter and drain materials. This area will require additional investigation to evaluate the quantity and quality of the sand and gravel deposit.

KEY POINTS

- A detailed investigation and assessment of the activity of faults near Calaveras Dam was completed.
- Seven trenches were excavated across the Quarry, Spillway, and Corral Point faults. Stratigraphic and structural relations exposed in the walls of the trenches were mapped in detail. Each trench was reviewed by geologists from DSOD and engineers from SFPUC.
- Radiocarbon dating of samples obtained from the trenches was performed to aid in the dating of soils and potential activity.
- Based on DSOD Fault Activity Guidelines:
  - the Quarry and Spillway faults, which are in the dam site, were concluded to be inactive;
  - the Gully Fault, located west of the dam site, was considered to be conditionally active; and
  - the Corral Point Fault, located south of the dam site, was concluded to be active.
- These conclusions provide the basis to develop appropriate design parameters for the replacement dam.

5.1 SCOPE OF FAULT INVESTIGATIONS

To develop appropriate design parameters, DSOD requires geological investigations of faults that cross the foundation of a proposed dam to evaluate geological evidence that shows the presence or absence of fault displacement within the past 35,000 years. A two-phase investigation of possible fault rupture near Calaveras Dam consisting of identification and characterization of significant faults was carried out for conceptual engineering. The activity of these faults was evaluated by following the Fault Activity Guidelines (Table 5-1) developed by DSOD (Fraser, 2001).

The initial phase of the investigation developed a preliminary assessment of the location and activity of fault strands in the vicinity of the dam footprint. The scope of this effort included review of existing relevant geologic literature, analysis of aerial photography, and geologic field mapping. A complete presentation of the data collected and interpretations can be found in a TM titled Fault Rupture Potential (Task 6.2) (WLA/URS, 2005).

The subsequent phase of investigation involved excavating several fault-normal trenches across the mapped traces of the Quarry, Spillway and Corral Point faults (Figures 5-1 and 5-2) to assess fault activity in the vicinity of the existing Calaveras Dam. The trenches were excavated by a rubber-tire backhoe and the southern wall of each trench was manually cleaned. After cleaning, the stratigraphic and structural relations exposed in each excavation were flagged and documented at a scale of approximately 1:40 (1 inch = 1 meter). For selected exposures, the northern wall was inspected and logged to document additional stratigraphic and structural information. After documenting the geologic relationships exposed in the excavation, each trench was reviewed by geologists from DSOD and engineers from SFPUC. The age of soils exposed in the trench walls was estimated based on stratigraphic position, soil characteristics, soil horizon development, and radiocarbon dating. Eleven charcoal and sediment samples obtained from deposits within the exposed trench walls were submitted for radiocarbon analysis to aid in the estimation of age of the deposits.

Table 5-1
DSOD Fault Activity Guidelines (from Fraser, 2001)

Fault Activity	Definition
Holocene Active Fault	- Surface or subsurface displacement within the Holocene epoch (i.e., the past 11,000 years)
Latest Pleistocene Active Fault	- No evidence of Holocene displacement is known - Has experienced displacement within the past 35,000 years
Conditionally Active Fault	- Displacement within the past 1.6 million years, however, displacement history during the past 35,000 years is not known, or - A pre-Quaternary fault that can be reasonably shown to have attributes consistent with the current tectonic regime
Inactive Fault [1]	- No surface or subsurface displacement within the past 35,000 years

[1] Requires demonstration that the fault trace is located confidently and is consistently overlain by unbroken geologic materials 35,000 years old or older, or through some other observation indicating lack of displacement (Fraser, 2001).

The second phase of the investigation also included additional reconnaissance field mapping and refinement of previous mapping that focused on (1) the Corral Point fault, (2) the eastern side of the reservoir, (3) possible fault-related geomorphic lineaments on the western side of the reservoir at Hill 1000, and (4) the principal strands of the central Calaveras fault between the southern end of the reservoir and Upper Calaveras Creek (Figure 5-1). The field objectives involved verification and refinement of mapped fault traces with characteristics that are consistent with the Calaveras fault system, especially faults along the margins of Calaveras Reservoir. The scope of this effort included interpretation of historical topographic maps, analysis of aerial photography, field mapping, and development of a local kinematic model. The results of this work contributed to the development of surface fault rupture scenarios and fault segmentation models.

5.2 FAULTS IN THE VICINITY OF CALAVERAS DAM

Besides the Calaveras fault, other faults in the vicinity of Calaveras Dam include the Quarry, Spillway and Gully faults (Figure 5-2). These faults differ from the principal traces of the central and northern Calaveras faults with respect to strike, sense of slip, geomorphic expression, and activity. All three of these faults strike more northerly or northeasterly than the main strands of the Calaveras fault, have substantial vertical separation, exhibit little or no geomorphic expression, and exhibit no evidence of late Quaternary displacement.

The Quarry fault, evident in quarry exposures west of Calaveras Creek (downstream of the dam), offsets the base of the Temblor Formation with an apparent down-to-the-west vertical separation along a near-vertical fault. North of this exposure, the Quarry fault bends to the north and has indistinct geomorphic expression along the west-facing flank of Quarry Hill (see Figure 4-4B).

Directly west of the spillway for Calaveras Dam, the Spillway fault strikes north toward the crest and eastern flank of Observation Hill (Figure 4-4C). Field mapping indicates that the fault strikes N10°E and locally dips about 70° west, although its straight trace suggests an overall near-vertical orientation. Cross-cutting relationships in bedrock show an apparent down-to-the-east sense of displacement on the Spillway fault, thus forming the western margin of a graben defined on the east by the Quarry fault. The Spillway fault also lacks young, fault-related geomorphic expression.

The mapped trace of the Gully fault coincides with a north-trending linear drainage on the southern flank of Observation Hill, and a notch along the ridgeline of Observation Hill (Figure 4-4C). This near-vertical, north- to northeast-striking fault juxtaposes Berryessa Formation shale on the west against Temblor Formation sandstone on the east, and has apparent down-to-the-east vertical displacement.

5.3 RESULTS OF FAULT INVESTIGATIONS

5.3.1 Summary

The results of the fault investigations are summarized in Table 5-2. DSOD concurs with the current assessment of fault activity shown in Table 5-2.

Table 5-2
Summary of Results of Fault Investigations

Fault	(DSOD 2002)	Current Assessment
Quarry Fault	Inactive	Inactive
Spillway Fault	Conditionally Active	Inactive
Gully Fault	Active	Conditionally Active
Corral Point Fault	Active	Active

5.3.2 Quarry Fault

Characterization of the Quarry fault involved detailed geologic mapping, trench investigations, and an assessment of fault activity based on DSOD criteria (Table 5-1; Fraser, 2001). The Quarry fault offsets the base of the Temblor Formation with an apparent down-to-the-west vertical separation along a near-vertical fault that strikes approximately N15°W, based on quarry exposures downstream of Calaveras Dam. Four fault-normal trenches were excavated across the northwestward projection of the Quarry fault and a subtle break in slope along the west-facing flank of Quarry Hill (Figure 5-3). Trenches across the projected fault trace show that north of the quarry exposures, the Quarry fault strikes more northerly (N5°W).

The Quarry fault was concluded to be inactive according to DSOD criteria on the basis of geologic relations observed in the trench exposures, local and regional geologic mapping, and by comparison to the characteristics of known active strands of the Calaveras fault. Support for this assessment includes: (1) the presence of undeformed colluvial deposits containing probable late Pleistocene soil horizons that overlie the western part of the fault zone; (2) indistinct fault-related geomorphic expression; and (3) specific fault characteristics, including strike and sense of displacement, that differentiate the Quarry fault from active strands of the Calaveras fault.

5.3.3 Spillway Fault

Detailed field mapping and excavation of two trenches across the northwestward projection of the fault along the northern flank of Observation Hill (Figure 5-4) were carried out to assess the activity of the Spillway fault. Directly west of the Calaveras Dam spillway, the Spillway fault strikes north toward the crest and across the eastern flank of Observation Hill. Bedrock outcrops inspected in the field show that the fault strikes N10°E and locally dips about 70° west. Structural relationships north of the spillway show apparent down-to-the-east vertical separation that places the Temblor Formation on the east against Franciscan serpentinite on the west. Youthful, fault-related geomorphic expression of the fault is not apparent in aerial photography or topographic data. At the trench site located north of Observation Hill, the Spillway fault is buried by ancient landslide deposits identified by preliminary mapping investigations (Geomatrix Consultants, 2002) and evident in trench exposures.

It was concluded that the Spillway fault is inactive according to the guidelines established by DSOD (Fraser, 2001) on the basis of: (1) an absence of fault-related geomorphic expression; (2) trench exposures of probable latest Pleistocene landslide deposits overlain by a thick package of colluvium that show no evidence of tectonic deformation; and (3) the northerly strike of the Spillway fault that contrasts with the northwest orientation of the active Corral Point and Calaveras faults.

5.3.4 Gully Fault

Characterization of the Gully fault is based on available geologic data, interpretation of aerial photography and field mapping summarized below. No detailed trench investigations were conducted across the Gully fault for this investigation. Geomorphic expression of the Gully fault is limited to a north-trending linear drainage on the southern flank of Observation Hill, and a notch along the ridgeline of Observation Hill (Figure 5-2). An extensive complex of landslide deposits north of Observation Hill obscures the trace of the fault. This near-vertical, north- to northeast-striking fault places Berryessa Formation shale on the west against Temblor sandstone on the east, and has apparent down-to-the-east vertical separation.

It is considered likely that the Gully fault is inactive according to DSOD guidelines (Fraser, 2001) based on the indistinct geomorphic expression of the fault, its similar structural characteristics to the Quarry and Spillway faults, and lack of evidence for Quaternary displacement. However, because of a lack of detailed subsurface investigations across the Gully fault, it is conservatively considered for conceptual engineering to be a conditionally active fault.

5.3.5 Corral Point Fault

Characterization of the Corral Point fault involved interpretation of aerial photography, pre-reservoir topography depicted on historic maps, and post-reservoir bathymetry as well as detailed geologic mapping, trenching, and review of existing geologic data. The Corral Point fault coincides with a north-trending, linear topographic saddle along the eastern margin of Calaveras Reservoir at Corral Point (Figure 5-5). The fault exhibits prominent geomorphic expression, including west- and east-facing topographic scarps, and vegetation lineaments. The fault offsets Cretaceous shale and Franciscan Complex mélange on the west against silica-carbonate rocks, serpentinite, and slivers of Cretaceous conglomerate on the east. Exposures documented in two trenches excavated across the Corral Point fault (Figure 5-5) revealed two faults: an eastern vertical fault strand with a strike of N15°W that offsets Holocene colluvial deposits on the west against Cretaceous conglomerate on the east; and a western east-dipping fault strand that strikes approximately N10°W and offsets Franciscan mélange on the west against Holocene colluvium on the east. Well-developed, sub-horizontal slickensides on the fault plane indicate predominantly right-lateral displacement of latest Holocene deposits.

An historic 1899 topographic map of Calaveras valley that predates the reservoir and bathymetric data from the reservoir in 2000 together provide evidence that the Corral Point fault steps westward or is structurally linked with the primary strand of the Calaveras fault (Figure 5-6). It may be inferred that the fault accommodates strain primarily through a seismic creep, although the possibility that surface fault rupture has occurred on the Corral Point fault cannot be precluded. On the basis of pronounced fault-related geomorphic expression and clear evidence for late Holocene displacement, it is concluded that the Corral Point fault is a primary strand of the Calaveras fault and is active according to DSOD criteria (Fraser, 2001).

5.4 FAULT RUPTURE POTENTIAL IN CALAVERAS VALLEY

The expected pattern of surface rupture during a large earthquake on either the northern or central Calaveras fault likely would involve deformation along the prominently expressed, NNW-striking faults in and near Calaveras Valley, including the Calaveras fault along the southeastern margin of the valley, the Corral Point fault, and the northern Calaveras fault where it traverses Leyden Creek north of Calaveras Reservoir. Fault strands in the southeastern part of Calaveras Valley are expected to produce oblique-normal slip, with components of dextral and down-to-the-west displacement. The Corral Point and Calaveras faults are expected to experience predominantly dextral slip. Secondary normal-oblique slip along the fault bordering the southwestern part of Calaveras Valley may occur, with components of dextral and down-to-the-east displacement. This rupture scenario reflects the structural model of the Calaveras Valley as a releasing bend containing several left-stepping *en echelon* NNW-striking active faults separated by small bends or stepovers.

It is not known with certainty whether coseismic rupture on either the northern or central Calaveras faults propagates to, into, or through the Calaveras Valley releasing bend. The uncertainty in possible rupture lengths of the northern and central Calaveras faults is addressed by considering three general structural models of fault segments near Calaveras Valley, involving (1) a single segmentation boundary, (2) an overlapping boundary, and (3) a non-overlapping boundary with a smaller, independent rupture segment in Calaveras Valley. All three of the models involve the N15°W-striking northern Calaveras fault in southern Sunol Valley, and the N35°W-striking central Calaveras fault in the Diablo Range. Maximum earthquake magnitudes of the rupture scenarios yield a weighted average maximum earthquake magnitude for the northern Calaveras fault of approximately M6.8, for the central Calaveras fault of M7.1, and for the Calaveras Valley independent rupture of M5.7.

The M7.1 is a median value for the central Calaveras fault, with a 50% probability of being exceeded. Based on the uncertainty in rupture length, and a standard deviation of 0.2 to 0.3 magnitude unit from empirical relationships, a MCE value of M7¼ for the central Calaveras fault has been adopted in the deterministic seismic hazard analysis for the conceptual design of the Calaveras Dam Replacement Project (URS, 2005c).

KEY POINTS

- The seismic design parameters were developed based on the Maximum Credible Earthquake (MCE) using a deterministic approach as required by DSOD.
- The MCE is a moment magnitude (**M**) 7¼ earthquake on the central Calaveras fault at a distance of 0.5 km (0.3 miles) from the dam site.
- The calculated 84th percentile MCE peak horizontal acceleration is 1.1 g. Corresponding ground motions were adjusted for directivity due to the near-field distance between the dam and the Calaveras fault.
- Reservoir triggered seismicity is considered to be unlikely for the replacement dam.

The selection and characterization of the MCE ground motions for Calaveras Dam is described in Seismic Source Characterization and Deterministic Ground Motion Assessment (TM 6.3) (URS, 2005c). The design ground motions are based on the ground motions estimated at the dam site in terms of a deterministic MCE. The deterministic approach involved the following steps:

- Identification of the potential seismic sources that could affect the site and estimation of the maximum earthquake that could reasonably be expected from these sources.
- Characterization of the ground motions that are likely to occur at the site due to the maximum earthquake for each seismic source based on selected ground motion attenuation relationships.
- Selection of the MCE with the potential for generating the strongest ground motions at the site.
- Characterization of the MCE in terms of peak ground acceleration, acceleration response spectra, time histories, and/or other parameters as deemed appropriate.

6.1 SEISMIC SOURCES

Based on available data, the most significant seismic source to the dam site in terms of strong ground shaking is the nearby Calaveras fault. The Calaveras fault is described in Section 4. The portion of the fault closest to Calaveras Dam could either be associated with the northern or central Calaveras faults. Because the central Calaveras fault will produce the largest earthquake based on its length [65 km (41 miles) versus 45 km (28 miles) for the northern Calaveras fault], it was adopted as the MCE, which will generate the highest ground shaking at the dam site. The MCE is an **M** 7¼ earthquake on the central Calaveras fault at a distance of 0.5 km (0.3 miles) from the dam site.

A second seismic source that was identified and evaluated was the San Andreas fault to the west. The MCE for this source is a **M** 8 earthquake at a rupture distance of 30 km (19 miles).

6.2 GROUND MOTION PARAMETERS

DSOD has adopted a "consequence-hazard" matrix that establishes guidelines for selecting the level of ground motions to be used in the seismic design of dams (Fraser and Howard, 2002). In this approach, 84th percentile ground motions are required for "extreme consequence" dams such as the Calaveras Dam and high slip rate faults (≥ 9 mm/yr slip rate) such as the central Calaveras fault. There is also precedent for designing high hazard dams using the 84th percentile ground motion.

Five percent damped horizontal acceleration 84th percentile response spectra were calculated from the maximum earthquakes on the Calaveras and San Andreas faults. The attenuation relationships developed by Abrahamson and Silva (1997), Sadigh *et al.* (1997), and Boore *et al.* (1997) were used to characterize the ground motions. The 84th percentile MCE horizontal spectrum adjusted for directivity due to the near-field distance of the dam to the Calaveras fault is shown on Figure 6-1. The adjustment was made using the modifications of Somerville et al. (1997) and Abrahamson (2000). The calculated 84th percentile MCE peak horizontal acceleration is 1.1 g for the central Calaveras fault. The ground motions for a **M** 8 on the San Andreas fault at a source-to-site distance of 30 km were lower than the motions for a central Calaveras MCE and, therefore, the Calaveras fault controls the MCE for the dam.

Time histories were developed based on spectral matching of the 84th percentile MCE horizontal fault-parallel component spectrum. Lucerne Valley station records of the 1992 **M** 7.3 Landers, California, earthquake were selected for the seed motions in the spectral matching. This well-known set of recordings contains forward directivity effects. These time histories were selected because the earthquake magnitude and recording distance are similar to those of the MCE and like the MCE, the corresponding ground motions will contain directivity. The developed time histories are shown on Figure 6-2.

6.3 RESERVOIR-TRIGGERED SEISMICITY

As early as 1945, a relationship was recognized between the level of water impounded by Hoover Dam and the frequency of earthquakes occurring in the vicinity of its reservoir, Lake Mead (Simpson, 1976). Since then, many such cases of reservoir-triggered seismicity (RTS) have been recognized around the world. The most commonly cited cases are at reservoirs created by Kariba Dam in Zambia, Aswan Dam in Egypt, Koyna Dam in India, and Kremasta Dam in Greece. Of the more than 30,000 reservoirs in the world, a disproportionately large fraction of the largest and deepest reservoirs have been associated with reported cases of RTS (Packer *et al.*, 1979). Through 1996, URS had compiled 145 reported cases of RTS worldwide. In California, seven reservoirs have been suggested to be cases of RTS, including Lake Oroville (Wong and Strandberg, 1996), which came to prominence with the occurrence of the 1 August 1975 M_L 5.7 Oroville earthquake (Toppozada and Morrison, 1982).

RTS is considered to be highly unlikely for the replacement dam because the underlying tectonic and hydrologic regime beneath the reservoir has reached equilibrium in the decades following impoundment. Furthermore, Calaveras Reservoir is considered to be a relatively shallow reservoir and RTS does not occur in such reservoirs. There is also no historical precedence that may suggest that the extended drawdown at Calaveras Dam would cause RTS when the full reservoir is restored.

The effects of reservoir-induced stresses are only capable of triggering failure along critically stressed faults. The size of an earthquake is controlled by the geometry and the size of the rupture area along such faults, and the pre-existing imposed state of stress. Because these parameters remain essentially unchanged in the presence of a reservoir, the maximum size of an earthquake on a specific fault will not change. Thus the largest RTS earthquake will not exceed the MCE already assigned to the faults considered significant to the reservoir, i.e., the largest RTS earthquake will not exceed the MCE of **M** 7¼ on the central Calaveras fault. RTS will not be a design issue for a new Calaveras Dam because the design ground motions will be based on the nearby MCE on the Calaveras fault.

KEY POINTS

- The Calaveras Dam Replacement Project will consist of:
  - An earthfill replacement dam located downstream of the existing dam;
  - An open-chute spillway in left abutment;
  - a new or rehabilitated intake tower, and
  - extension of the existing outlet.
- The downstream replacement dam will be founded on bedrock, and excavation depths are estimated to be as much as 40 feet in the left (west) abutment Temblor Sandstone and 80 feet in the right (east) abutment Franciscan Complex.
- A 70-foot deep concrete cutoff wall or multi-row grout curtain will intercept seepage through the upper zone of high hydraulic conductivities in the Temblor Sandstone. A 100-foot deep grout curtain will intercept seepage in the mélange of the Franciscan Complex.
- The shells of the dam will be constructed using Temblor Sandstone generated from the required spillway excavation. The core will be widened at the top so that the potential for enlargement would not be precluded.
- A filter and drain system is included to prevent piping of embankment materials and to control seepage through the dam and foundation.
- Maximum seismically-induced deformations were calculated to be about 1¾ feet and would not impair the function of the dam.
- An instrumentation system consisting of piezometers, inclinometers, survey monuments, seepage measurement weir, reservoir level measuring device, strong motion accelerographs, and an automatic data acquisition system (ADAS) would provide for long-term performance monitoring.
- The project will include a new intake tower for seismic safety, improved operations and maintenance.

7.1 GENERAL SITE PLAN

The general site plan for the replacement project is shown on Figure 7-1, which shows the locations of the dam, spillway, borrow areas, disposal areas, staging and stockpile areas, and the potential haul road from Borrow Area E to the dam site. These areas are discussed in the following sections.

The description of the replacement dam and appurtenant works is summarized in Table 7-1. Table 7-1 is similar to Table 2-1 that describes the existing dam and appurtenant works. Most of the parameters between the replacement dam and the existing dam remain unchanged. Where changes will occur with the replacement dam project, they are noted in Table 7-1.

Table 7-1
Description of Replacement Calaveras Dam and Appurtenant Works

Owner	City and County of San Francisco
Stream	Calaveras and Arroyo Hondo Creeks
Location	Approximately 1 mile upstream from junction of Calaveras and Alameda Creeks. Part in Alameda and part in Santa Clara County.
Purpose	Storage for municipal and domestic use
Drainage Area	98.4 square miles (Calaveras/Arroyo Hondo basin)
	35 square miles (Alameda Creek basin at diversion point)
Mean Annual Precipitation	28 inches
Probable Maximum Flood Peak Inflow*	49,521 cfs (includes Alameda Creek Diversion flow of 730 cfs)
Probable Maximum Storm	72-hour duration, 30.8 inches rainfall
Reservoir Pool Elevations**	
Streambed	546.2 ft.
Minimum Pool (deadpool)	600.6 ft.
At Spillway Crest	756.2 ft.
Probable Maximum Flood Pool	774.8 ft. (existing dam: 776.8 ft.)
Reservoir Areas	
At Spillway Crest	1,435 acres
Probable Maximum Flood Pool	Approximately 1,600 acres
Reservoir Storage	
At Spillway Crest	96,850 ac-ft (includes sediment)
Probable Maximum Flood Pool	approximately 135,000 ac-ft (not considering sediment)
Length of Reservoir	3.2 miles
Dam	
Type	Earthfill, clay core (existing dam: partly hydraulic fill)
Elevation-Top of Dam	778 ft. (existing dam: 778.6 ft)
Freeboard-Spillway Crest to Top of Dam	21.8 ft. (existing dam: 22.4 ft.)
Structural Height, foundation to dam crest	220 ft.
Height, d/s toe to dam crest	210 ft.
Side Slopes	Upstream: 2.5H:1V (existing dam: 3H:1V and 5H:1V) Downstream: 2.25H:1V (existing dam: 2¾:1V average)
Length of Crest	1,130 ft. (existing dam: 1,200 ft.)
Base Width	1,100 ft. (existing dam: 1,510 ft.)
Crest Width	76 ft. (existing dam: approx. 80 ft.)
Total Volume of Embankment	2.3 million cy (existing dam: 3.5 million cy)
Freeboard above Probable Maximum Flood Pool	3.2 ft.

---

[*] Probable Maximum Flood (PMF) parameters reflect calculations performed by URS in 2004. Refer to Section 3.5.

[**] Elevations are in USGS Datum. Subtract 3.636 feet to convert to San Francisco Water Department (SFWD) datum also referred to as Crystal Springs Datum.

Table 7-1 (continued)
Description of Replacement Calaveras Dam and Appurtenant Works

Spillway	
Type	New concrete lined-ungated (existing dam: straight-trapezoidal-concrete lined-ungated)
Location	Left abutment of dam
Crest Elevation	756.2 ft (same as existing)
Crest Length	120 ft. (existing dam: 155.12 ft.)
Spillway Length (Includes Stilling Basin)	1,410 ft; stilling basin length is approx. 150 ft. (existing dam: 1,466.7 ft.)
Outlet Works	
Type	New concrete tower interior diameter 16-feet. 72-inch diameter vertical riser (standpipe) to replace existing 12-feet diameter tower.
Location	Left side of dam
Elevation of Intakes/Intake Valve Description	
Drain, El. 602.21 feet	Two new 30-inch (or larger) diameter gate or knife gate valves in series
Adit No. 1, Centerline El. 663.55 feet	Two 48-inch diameter knife gate valves in series. (It may be possible to salvage one valve from existing tower.)
Adit No. 2, Centerline El. 699.13 feet	Two 48-inch diameter knife gate valves in series. (It may be possible to salvage one valve from existing tower.)
Adit No. 3, Centerline to be determined	New adit(s) to replace existing 60-inch diameter adit with centerline elevation 727.19.
Conduit	0.5-inch thick 72-inch diameter steel pipe from intake tower to outlet valve in stilling basin: 1,780 feet; includes 1176 feet of existing conduit and conduit extension through foundation of new dam.
Tunnel Length	1,006 feet to outlet portal
Tunnel Grade	0.0060
Total Discharge Capacity, Conduit:	
Reservoir Elevation at Spillway Crest	Approximately 1000cfs using Fixed Cone Valve
Bifurcations	1. One leg conveys stream releases to 72-inch diameter fixed cone valve discharging to stilling basin 2. Other leg connects to pipeline(s) continuing approximately 20,500 feet to SVWTP. 3. A smaller valve (size to be determined following discussion with the resource agencies) would be used to make stream maintenance releases to the creek.

7.2 DAM

The conceptual design of the earthfill dam includes estimation of foundation levels, foundation treatment requirements, embankment zoning, foundation seepage control, stabilization of landslides, and instrumentation. These design components are described in the following sections.

7.2.1 Foundation Objectives and Treatment

Objectives

The replacement dam will be founded on bedrock. Dam foundation levels and requirements are based on the zones within the dam and are dependent on foundation rock strength, degree of weathering, and deformation. The degree of rock weathering is defined in Table 7-2 and was used, along with fracture intensity and strength, to estimate dam foundation levels.

Table 7-2
Rock Weathering/Alteration

Description	Recognition
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Extremely Weathered/Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although original fabric may be intact; material can be granulated by hand
Highly Weathered/Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 2-inch-diameter sample can be broken readily by hand across rock fabric
Moderately Weathered/Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 2-inch-diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered/Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh	Rock shows no discoloration, loss of strength, or other effect of weathering/alteration

The foundation objectives for the dam will be as follows:

- The core and filter zones will preferably be founded on slightly weathered to fresh rock. This rock is considered to be groutable and discontinuities in its surface can be treated because the rock has less weathering products in the discontinuities than the overlying more weathered rock. Determination of this objective for the Franciscan shale mélange and serpentinite will require the presence of an experienced engineering geologist during excavation for the core and filter zones.
- The shell zones will be founded on moderately/highly weathered to fresh rock. This rock is expected to have sufficient strength to support the shells of the dam.

Foundation levels were estimated based on the weathering and fracture intensity observed in cores retrieved from the borings within the dam footprint. Contours of foundation levels for shells and core/filter are presented in the Geotechnical Interpretive Report (URS, 2005b). A summary of the range of excavation depths to reach foundation levels for the replacement dam is shown in Table 7-3.

Table 7-3
Estimated Dam Foundation Levels[1]

Zone	Temblor Sandstone	Franciscan Complex
Shells	15 feet to 25 feet	15 feet to 70 feet
Core/Filter	20 feet to 40 feet	35 feet to 80 feet

[1] Refer to Geotechnical Interpretive Report (URS, 2005b); estimated depths rounded to nearest 5 feet.

Foundation Treatment

The Temblor Sandstone contains intensely fractured zones with highly weathered, very weak sandstone and some clay-filled fractures that will likely be erodible. Franciscan Complex shale is soft and also would be erodible. Joints and other foundation discontinuities will need to be treated to prevent piping of embankment materials into open joints and other foundation discontinuities. Filters will also be required under the shell zones to prevent loss of materials into open joints. Joints in the foundation of the core will need to be cleaned out and filled with dental concrete, and narrow joints filled with slush grout. In addition, the core foundation will need to be cleaned for geologic mapping and inspection, and a final clean up will be required just prior to fill placement.

Shale mélange and serpentinite will slake when subjected to prolonged exposure. As such, the surface of these rocks will require protection to prevent these materials from slaking or otherwise deteriorating upon exposure. Such protection would include leaving a sacrificial layer 1 to 2 feet thick that will be removed immediately prior to placing embankment fill. Lean concrete or shotcrete mats will be placed on the foundations of concrete structures to control slaking.

7.2.2 Excavation

The Temblor Sandstone is expected to form a relatively uniform foundation surface that generally can be excavated with conventional equipment (scrapers and dozers). The foundation excavation in the Franciscan Complex will be much more of a challenge than in the Temblor Sandstone. Excavation would likely be carried out with dozers, excavators, loaders and trucks. The variable depths of weathering and hard blocks within the mélange matrix will tend to produce an irregular foundation surface, with the larger hard blocks protruding through the softer matrix material. Excavation operations that minimize foundation irregularities will be required. Excavation to remove or shape hard blocks to create a relatively uniform foundation surface is expected in the core foundation. Excavation of the Franciscan Complex will require continuous presence of an experienced engineering geologist during construction.

7.2.3 Existing Dam/Cofferdam

The existing dam will be used as a cofferdam during construction of the replacement dam. A portion of the downstream shell will be cut back to a 2H:1V slope without removing the existing dam crest. Dewatering wells may need to be installed to lower the phreatic surface within the remaining dam to increase stability. The cofferdam would allow the reservoir to remain in operation at the present restricted level and would provide 100-year flood protection during construction as described in Section 3.7.2. Stability analysis of the cofferdam during construction is presented in Appendix D.

At the end of construction, the cofferdam would be leveled off to approximately elevation 705 feet. The excavated material from the cofferdam would be placed and compacted between the downstream slope of the cofferdam and upstream slope of the replacement dam. Alternatively, excess excavated materials from the spillway excavation (Temblor Sandstone) could be placed and compacted between the cofferdam and replacement dam. In this case, the excavated material from the cofferdam would be placed in a disposal area as discussed in Section 7.6.2. The decision on the type of material to be placed will be determined during final design. Rock would be placed on the fill surface between the two dams to reduce the potential for turbidity in the reservoir when the depth of water above the fill is shallow.

7.2.4 Embankment

The configuration of the replacement dam is based on embankment dam precedent, material availability and on results of stability and seismic deformation analyses presented in Appendix D. Conceptual design plans and sections are illustrated on Figures 7-2 through Figure 7-6. The dam would have an upstream slope of 2.5H:1V and a downstream slope of 2.25H:1V. The crest width of the dam would be 76 feet, which would accommodate a potential future enlargement.

The core (Zone 1) of the dam would be constructed of fine-grained alluvial material from Borrow Area E at the south end of the reservoir. The core would be vertical and would have upstream and downstream slopes of 0.25H: 1V.

Sand and gravel will form the chimney and blanket filters (Zone 2) and chimney and blanket drains (Zone 3). These materials would be imported from commercial sources or they could potentially be obtained from young alluvial fan deposits in the vicinity of Borrow Area E as discussed in Section 4.5.5. A 15-foot-wide chimney filter (Zone 2) would be located downstream of the core to prevent piping of the core into the 10-foot-wide chimney drain (Zone 3). To convey seepage water from the embankment and the foundation, a 5-foot-thick blanket drain (Zone 3) would be placed on the downstream shell foundation. Three-foot-thick filters (Zone 2) would be placed above and below the blanket drain to prevent soils from being washed into the blanket drain. These dimensions are based on experience for similar-sized embankment dams constructed in California.

The shells (Zone 4) of the dam would be constructed using Temblor Sandstone generated from the required spillway excavation. This material is expected to breakdown to an earthfill material.

A 4-foot-thick riprap layer (Zone 6) would be placed on the upstream slope for protection against wave erosion (Figures 7-4 and 7-6). A 1½-foot-thick bedding layer (Zone 5) would be placed under the riprap to prevent erosion of the underlying Zone 4 embankment soils.

7.2.5 Results of Stability and Deformation Analyses

Results of static stability analyses of the replacement dam are presented in Appendix D. The static loading conditions analyzed included long-term steady-state seepage, emergency and operational reservoir drawdown, and pseudo-static seismic loads. A dynamic response analysis was conducted to estimate the seismically-induced slope deformations that can be expected to result from the design earthquake.

As shown in Table D-3 of Appendix D, the results of static stability analyses indicate that the calculated safety factors for the dam under long-term steady-state seepage and drawdown loading conditions exceed the minimum design criteria established for the project. The maximum calculated seismically-induced deformation is about 1¾ feet, which would not impair the function of the dam.

7.2.6 Foundation Seepage Control

Foundation grouting of the mélange of the Franciscan Complex would consist of a two-line grout curtain. Curtain grouting would be done in a split-spacing sequence. It was assumed for estimating purposes that the average final spacing of grout holes would be at 10-foot centers. For conceptual design, the curtain would extend 100 feet into the foundation measured perpendicularly to the excavated surface. The orientations of the grout holes in one line would differ by approximately 40 degrees from that of the other line (i.e., each line would have hole orientations at 20 degrees from vertical, but in opposing directions). This grout hole orientation will increase the effectiveness of the curtain intersecting and grouting foliation, shears and discontinuities with varying attitudes. A 10-foot-deep concrete cutoff wall would be constructed along the alignment of the curtain to act as a grout cap and to act as a positive cutoff of seepage at shallow depth below the foundation surface. Grout pressures will need to be closely monitored to minimize the potential for ground heave and hydrofracturing of the foundation rock.

A cutoff wall or multi-row grout curtain will be necessary in the left abutment where the dam will be founded on the Temblor Sandstone. The decision to employ a grout curtain or a secant wall option will be further explored during final design. A 70-foot deep concrete wall or grout curtain would intercept seepage through the near-surface zone of high hydraulic conductivities in the Temblor Sandstone (see Section 4.4.1). The concrete wall could be a concrete secant pile wall, concrete diaphragm wall, or a jet grout wall (URS, 2004d). The base of the wall or curtain would be founded in the lower permeability sandstone underlying the zone of high hydraulic conductivity. For conceptual design, the concrete secant pile cutoff wall option was selected because it would provide a more positive cutoff than a jet grout wall or permeation grout curtain. The extent of the cutoff is shown in plan (Figure 7-3) and profile (Figure 7-5).

The following is a description of the key features of the concrete cutoff wall and grout curtain. Precedent and constructability issues were discussed with representatives of specialty ground modification contractors (Case Foundation Company, Keller Ground Engineering, Hayward-Baker, TreviIcos Corporation, and Nicholson-Rodio Company).

Concrete Cutoff Wall

Secant pile walls up to 120-feet deep have been installed as cutoffs in difficult rock conditions on the abutments of dams. A secant pile wall consists of a row of primary caissons installed at a center-to-center-spacing less than the caisson diameter. Concrete is tremmied into the primary holes. Secondary caissons are then drilled midway between the primary caissons partially overlapping them. The secondary caissons are backfilled with concrete to form a continuous concrete seepage barrier. For a 70-foot deep wall, the caisson diameter would be on the order of 20 to 24 inches. Installation would require drilling equipment and a support crane weighing as much as 200 tons. The wall could be constructed on the steep slope of the left abutment from a series of excavated benches or from a sloped concrete guide slab placed directly on the core trench foundation. Construction from a sloped concrete guide slab would require moving the drilling equipment and support crane up and down the slope using an engineered winching system.

Multi-Row Grout Curtain

The grout curtain construction program could consist of a combination of low mobility grouting followed by permeation grouting. Low mobility grouting involves high-pressure injection of a stiff sand/cement grout through drill holes to fill the larger discontinuities in the rock mass. Tight control and monitoring of injection pressures are required with low mobility grouting to reduce the risk of ground surface heave. Permeation grouting involves lower injection pressure and a fluid cement-based grout to fill the finer discontinuities that could not be filled by low mobility grouting. The grout cutoff would require at least one row of closely spaced low mobility grout curtains located on each side of the permeation grout curtain to provide confinement for subsequent permeation grouting. Grouting is typically performed until the hydraulic conductivity has been reduced to a target lugeon level that is determined during final design and has DSOD concurrence. Multiple lines of permeation grouting may be required to achieve closure.

Because it is difficult to confine treatment to a specific volume of rock, multiple rounds of grouting with progressively closer spacing of holes may be required. Consequently, grouting progress can vary over a wide time span, particularly in a pervious rock mass. The potential exists for the grouting operation to take longer than estimated, thus impeding the placement of earthfill and affecting the overall construction schedule and cost.

Although grouting may be significantly less expensive, it offers less confidence in achieving a continuous seepage cutoff, and closure may be difficult to achieve if large discontinuities are present. This construction option will be evaluated further during final design.

7.2.7 Stabilization of Right Abutment Landslide

Existing landslides are present in the right abutment Franciscan Complex materials, both upstream and downstream of the existing dam as described in Section 4.4.3. Foundation excavation would remove a portion of one such landslide located on the right abutment approximately 400 feet downstream of the existing dam. To prevent reactivation of the slide because of the excavation, stabilization of the landslide involving a combination of shaping or removal, reinforcement, and surface and subsurface drainage facilities will be required. The landslide stabilization options will be further explored during final design.

7.2.8 Instrumentation

Instrumentation will be installed in the dam embankment and foundation, downstream of the dam, and the right abutment landslide (Figure 7-7). The objectives of instrumenting the dam include developing physical data for comparison to assumptions made for the design analyses; anticipated behavior based on the studies; and monitoring of dam performance during construction, first filling of the reservoir, and long-term operation of the project. The selection of the type and location of instrumentation is based on measurement of specific engineering parameters that need to be monitored. These include deformation, seepage flows, piezometric levels, pore-water pressure and seismic response.

Instrumentation data will initially be used to evaluate whether constructed conditions are consistent with the design assumptions. During long-term operation of the project, instrumentation data will be used to monitor the performance of the dam. As data are compiled, trends under normal operation will be established, and the significance of variations under unusual events or loads, such as earthquakes, can be evaluated.

Primary considerations in the selection of the types of instrumentation are the reliability and the accuracy needed to meet the objectives presented above. In addition, the instrumentation will be selected to minimize disruption to construction operations to the fullest practical extent. Selection of specific instruments, development of specific numbers and locations of instrumentation, and development of details and specifications will be completed during final design. Final selection of instrumentation will be coordinated with SFPUC for development of the automated data acquisition system (ADAS). Specifications for instrumentation will emphasize the performance and durability of each instrumentation system, as well as the need for low maintenance and compatibility with SFPUC's existing operations. Table 7-4 lists the types and purpose of instrumentation recommended for installation at the dam. Figure 7-7 shows typical locations for the proposed instrumentation.

Table 7-4
Summary of Instrumentation

Type	Purpose
Transducer Piezometer	- Piezometric level
Open Standpipe Piezometer	- Piezometric level
Inclinometer	- Lateral Deformation
Survey Monument	- Three-dimensional surface deformation
Weir	- Seepage rate
Strong Motion Accelerograph	- Earthquake acceleration time history
Reservoir Level Device	- Reservoir level change

The monitoring frequency of the instrumentation systems will be developed as part of final design studies and will be part of an instrumentation monitoring plan. Those studies will be coordinated with SFPUC so that the monitoring requirements can be integrated into the operation of the project.

The frequency of monitoring for each instrumentation system is expected to vary during the life of the project. During construction and first filling of the reservoir, readings will be taken and evaluated at relatively frequent intervals so that any anomalous trends can be quickly identified and evaluated. As conditions stabilize and trends of instrumentation readings become established, the frequency of readings will generally be reduced. However, instrumentation systems will need to be monitored immediately after the occurrence of unusual events such as earthquakes or large rainstorms.

7.3 SPILLWAY

For a downstream replacement dam, a number of alternative open channel spillway arrangements were considered. Layout plans were developed for spillway options using side channel approaches on both the right and left abutments (URS, 2004b). In response to comments in CTAP Report No. 2 (CTAP, 2004b) a conceptual layout of an open channel curved spillway located in the left abutment was developed to optimize excavation (i.e., balance excavation volume with the fill requirements for embankment shell materials; see Section 7.2.4). Another option that will be considered during final design includes an extended approach channel and straight chute. The final spillway layout will be determined from hydraulic analysis and model studies to be performed during final design.

The curved spillway would have a 120-foot crest length that reduces in the curved portion to a chute width of 60 feet and terminates in a stilling basin (see Figures 7-3 and 7-5). The overall spillway length from the crest to the end of the stilling basin is approximately 1,410 feet. The curved alignment would require a combination of numerical and physical hydraulic modeling to confirm hydraulic performance as part of final design.

The majority of the spillway would be excavated within Temblor Sandstone although a small portion of the cut slopes on the west side of the approach channel would be in serpentinite. Cut slopes in the Temblor Sandstone for the chute would be 1.3H:1V overall (1H:1V between 15-foot-wide benches at 50-foot vertical intervals).

7.4 OUTLET WORKS

The existing outlet facilities and intake tower are discussed in Section 2.4. The Calaveras Dam Replacement Project would require extension, modifications, improvements and replacement of these outlet facilities as described below. Two options were considered for the intake tower[13] and shaft (tower). The first would involve upgrading the existing tower to improve long-term reliability, operability and maintainability and to meet present seismic stability requirements. The second would consist of replacing the existing tower with a new tower. For seismic safety, improved operations and maintenance, a new intake tower was considered to be the preferred alternative and was adopted for the Calaveras Dam Replacement Project. The new intake tower is described in the sections that follow.

7.4.1 Outlet Conduit

Because the replacement dam footprint extends downstream, it is necessary to extend the outlet conduit approximately 500 feet downstream of the existing outlet tunnel portal. The steel outlet conduit extension would be placed in a trench excavated in rock under the new replacement dam. After conduit installation, the trench would be backfilled with concrete. No improvements are envisioned for the conduit upstream of the existing tunnel portal.

---

[13] Previous SFPUC design drawings refer to the intake tower as the outlet tower. Industry convention adopted by the U.S. Bureau of Reclamation, U.S. Corps of Engineers and others refer to this structure as an intake tower; hence, in this report and drawings, intake tower will be used.

7.4.2 Downstream Release Valves

Similar to the present arrangement, the outlet conduit would bifurcate immediately downstream of the new dam. One leg would connect to the conduit used to convey releases to the SVWTP. The other leg would connect to the relocated 72-inch diameter fixed cone valve. The cone valve would discharge to a portion of the spillway stilling basin designed to accept and dissipate the energy associated with releases from the valve. In addition, a smaller valve (size to be determined following discussion with the resource agencies) would be used to make stream maintenance releases to the creek. The relocation would also include shutoff/isolation valves (likely located in valve vaults similar to the existing arrangement) and provisions for draining and accessing the outlet conduit. To prevent uncontrolled flow of water from Calaveras Reservoir in the event of a break on the Calaveras Pipeline, provision for automatic closure (seismic or high-velocity activated) will be provided on the pipeline leg connecting to the SVWTP.

7.4.3 Intake Tower

A new tower will be constructed along the alignment of the existing outlet conduit with centerline approximately 60-feet downstream from the centerline of the existing tower as shown on Figure 7-8. Like the existing tower, the structure would consist of a circular shaft in rock connected to a reinforced concrete tower. The arrangement would be similar to the existing tower, but it would be designed to meet present seismic requirements and to facilitate operation and maintenance. The key features of the new intake tower include:

- Finished interior diameter of 16 feet (compared to existing 12-foot diameter) in order to provide additional room for accessing and maintaining the operating valves.
- The base of the shaft would be at approximate elevation 694. A 72-inch diameter riser (compared to the existing 60-inch diameter riser) would connect to the existing 72-inch outlet pipe to improve hydraulic performance under high discharge conditions.
- The existing 30-inch drain line, and 48-inch Adits 1 and 2 would be connected from the existing shaft to the new riser within the new shaft with new piping and shutoff valves.
- Rather than connecting through the existing shaft, it is envisioned that a new 60-inch adit would connect directly to the reservoir. However, the existing drum screens (for fish protection) would be reused if possible.
- The new tower would include an elevator or hoist system to facilitate access to the lower level valves.
- A new bridge would connect the tower to the existing access road.
- The existing shaft would be backfilled with lean concrete up to the ground surface. The tower itself (that portion above the ground level) may be demolished or left in place depending on cultural resource requirements.

During final design, design criteria will be developed for the outlet works access, hoisting equipment, valve service and controls, bridges duty, and service life.

The intake tower adit concept was developed to be consistent with existing operational requirements and to minimize the overall cost. Development of additional adits below elevation 690 would require "lake tap" construction because agreements with California Department of Fish and Game preclude drawing down the reservoir below this level. Above this level, the need and potential for improved water quality versus the cost of additional adits will be considered in final design.

7.5 OPERATION OF RESERVOIR DURING CONSTRUCTION

As presently envisioned, during construction of the new replacement dam, the reservoir would continue to be operated similar to current restricted operations (level maintained between elevations 690.0 and 705.45 feet). It would be operated to beneficially utilize the natural inflow whenever possible. Construction of the new intake tower and connection with the existing outlet system will have to be scheduled to maintain an operational outlet during the rainy season. In addition, during times of heavy inflow, the reservoir would need to be operated more aggressively than at present to maintain and/or restore the reservoir to a level at or below elevation 705 feet. Should the reservoir start to rise above elevation 705 feet, the outlet system would be utilized to restore the level back to the restricted operating limits at quickly as possible through releases to Calaveras Creek.

The existing dam would be maintained in a condition such that it can safely retain an inflow equivalent to the 100-year storm event (elevation 737.6 feet) until such time as the replacement dam is completed to this elevation.

7.6 CONSTRUCTION CONSIDERATIONS

7.6.1 Earthworks

The principal earthworks of the project involve excavations for the dam foundation and spillway at the left abutment and embankment construction. Excavation of the dam foundation would progress from the top of the left abutment, right abutment, and cofferdam to the valley floor. The majority of the excavation would likely be done by excavators loading into dump trucks for hauling to a disposal area.

Excavation for the spillway would progress from the top of Observation Hill down to the spillway level. Although most of the Temblor Sandstone material should be rippable it may be more economical to drill and blast for borrow operations. The borrow material would be loaded into dump trucks using large front-end loaders and hauled to the dam site using a series of temporary haul roads constructed along the southwest side of Observation Hill. The sandstone would be dumped and spread within the shell zones and compacted with either tamping-foot or vibratory rollers. The sandstone will need to be pre-wetted in the borrow area and then final moisture conditioned on the dam. The edges of the spillway excavation would be rounded off and contoured to blend into the southwest and northeast sides of Observation Hill.

Core materials from Borrow Area E may be excavated by large excavators loading into dump trucks. The material would be hauled to the dam along the east side of the reservoir (Figure 7-1), or barged across the reservoir. Pre-moisture conditioning would occur in the borrow area. The material would be spread out on the fill with tractors, moisture conditioned, disked and compacted. The material would be compacted using tamping-foot rollers.

Importing of filter and drain materials could commence soon after notice to proceed and continue through the duration of embankment construction. These materials would be stockpiled in one of the staging areas for later use. The filter and drain materials would be loaded from the stockpiles into trucks and hauled to the dam. The materials might be placed in their respective zones using belly dump trucks and would be spread with rubber-tired loaders. The materials would be compacted with a smooth drum vibratory roller.

Riprap would be produced from Borrow Area B using drilling and blasting methods. It was assumed that riprap bedding materials would also be produced from Borrow Area B using a crushing and screening operation. Riprap and riprap bedding should be placed simultaneously with fill placement. The riprap and rip bedding materials could be loaded onto dump trucks and hauled onto the dam. The riprap bedding should be placed on the upstream slope of the dam with limited spreading to prevent segregation. The riprap would be placed and selectively positioned on the riprap bedding using an excavator working from the fill level.

Water will be required during construction for moisture-conditioning of the embankment materials and for dust control on haul roads and in the borrow areas. The reservoir will be the source of construction water.

The main earthworks quantities were computed from the conceptual design drawings (Figure 7-3 and Figure 7-4) using the Autodesk Land Desktop 3 CADD program and independently checked using average end area methods. Allowances for secondary quantities were based on judgment. The quantities represent in-place volumes, either in-situ or in-bank, as appropriate.

A material balance (or flow) diagram was prepared to show material quantities associated with the required excavations, borrow area excavations, and embankment construction (see Figure 7-9). The diagram indicates the potential range in the amount of waste material to be disposed of and the sources of these materials, where construction materials for the dam would be obtained, and the on-site reserve in the construction materials. Where a reserve is indicated on the diagram, the material would typically be left in place (in-bank) unless required for dam construction. Estimates for material bulking and shrink/swell along with amount of unacceptable construction material are indicated on the diagram.

7.6.2 Disposal Areas

Disposal areas would be required for permanent storage of unsuitable and excess material generated from required excavations. The disposal volume is currently estimated to be about 4.4 million cubic yards. Five potential disposal areas have been identified. The number of disposal areas to be used will depend on many factors including environmental constraints and cost. Table 7-5 lists the location, maximum disposal volume, maximum area of disturbance, and maximum elevation for each of the disposal areas. The location of each disposal area is shown on Figure 7-1.

Construction considerations and environmental impacts associated with each of the disposal areas are summarized in the following paragraphs.

Table 7-5
Summary of Disposal Areas

Disposal Area	Location	Estimated Maximum Disposal Volume (CY)	Estimated Maximum Area of Disturbance (acres)	Estimated Maximum Elevation (feet)
1	Borrow Area C	1,900,000	37	940
2	Between Existing and Downstream Replacement Dams	1,100,000	0[1]	720
3	Drainage in reservoir west of existing dam	800,000 3,800,000	0[2] 20[2]	756 825
4	Dam Tenders Residence	1,100,000	27	1,000
5	Borrow Area E	2,000,000[3]	0[2]	756

[1] Area already included in disturbance area for construction of downstream replacement and expanded dams.

[2] Assumes that area below normal maximum water surface (elevation 756 feet) is not considered a disturbance area.

[3] Assumes a 5-foot thickness of disposed material between elevations 710 and 750 within the reservoir area.

Disposal Area 1

Disposal Area 1 is located in a draw north of Observation Hill in the vicinity of Borrow Area C. The haul distance to this disposal area would range from about 0.5 to 1.0 miles with a maximum elevation gain of about 360 feet. The disposal area would be contoured to blend into the topography. Topsoil stripped from the area prior to placement of waste materials would be placed on the final grade to facilitate upland restoration with native vegetation.

Disposal Area 2

Disposal Area 2 would take advantage of the space between the cofferdam and the replacement dam. Construction sequencing may allow for the use of a portion of this area for disposal of materials generated during excavation of the cofferdam and dam foundation. Excess material generated from the spillway excavation and materials removed from the existing dam at the end of construction could be wasted at this location. As stated in Section 7.2.3, rock would be placed on the fill surface between the two dams to reduce the potential for turbidity in the reservoir at the times when the depth of water above the fill is shallow.

Disposal Area 3

Disposal Area 3 is located in a draw to the west of the dam along the Calaveras Fault. The haul distance to this disposal area would range from about 0.6 to 1.0 miles with a maximum elevation gain of about 260 feet. Topsoil would be stripped from the area prior to placement of waste materials and stockpiled for later placement on the final grade to facilitate restoration. An earthfill dike would be constructed at the downstream extent of the draw with the toe located at the restricted reservoir level. Waste and excess materials would be placed upstream of the earthfill dike filling the draw. The final grade of the disposal area may be above the restored reservoir water level (elevation 756 feet). The final grade of the disposal area could be configured to restore wetland and riparian vegetation if it is above elevation 756 feet.

Disposal Area 4

Disposal Area 4 is located on a terrace on the east side of the reservoir and includes one of the primary staging areas for construction. The haul distance to this disposal area would range from about 0.6 to 0.8 miles with a maximum elevation gain of about 440 feet. The disposal area would be contoured to blend into the topography. Topsoil stripped from the area prior to placement of waste materials would be placed on the final grade to facilitate upland restoration with native vegetation.

Disposal Area 5

Disposal Area 5 is located in the reservoir area near Borrow Area E. Due to hauling costs, use of this disposal area for disposal of materials generated from cofferdam and dam foundation excavation would increase construction cost. However, this disposal area might be used efficiently for disposal of a portion of the excess materials generated from spillway excavation, which may occur concurrently with core production. Hauling units transporting core materials to the dam could return to Borrow Area E filled with excavated waste materials. Topsoil would be stripped from the area prior to placement of waste materials and stockpiled for later placement on the final grade to facilitate restoration. During final design, placement of disposal materials in the excavated areas of Borrow Area E will be evaluated.

7.6.3 Borrow Areas

Four borrow areas have been identified in the vicinity of the dam site as shown on Figure 7-1. Core materials could be produced from Borrow Areas C, D and E. However, Borrow Areas C and D appear to contain insufficient quantities of colluvium for core material (see Section 4.5). Therefore, core materials would need to be produced from Borrow Area E. As stated in Section 4.5.5, this borrow area would be developed to avoid the chemically-impacted soils and groundwater resulting from the previous Calaveras Test Site. During construction, soil samples down-gradient of the Test Site would be chemically tested for the constituents of concern to confirm avoidance.

The haul route from Borrow area E to the dam site is shown along the east shore of the reservoir. The east shore was selected over the west shore because there are existing roads that can be graded for haul roads and the shoreline appears to be less irregular than the west side. The haul route is approximately 4.75 miles long. A temporary bridge (floating bridge shown on Figure 7-1) would be required across Arroyo Hondo.

Shell materials would be produced from the spillway excavation, which is located in the eastern portion of Borrow Area A. Riprap and possibly riprap bedding would be produced from blueschist and greywacke found in Borrow Area B2. Development of portions of Borrow Area B2 would require removal of overlying Temblor Sandstone (Borrow Area B1) in order to obtain the blueschist and graywacke.

Riprap materials that could be salvaged from the existing dam include riprap from the upstream face of the dam and rockfill placed during buttressing in 1974. The estimated in-situ quantities and quantities available from the borrow areas are summarized in Table 7-6.

Table 7-6
Estimated Borrow Material Quantities

Borrow Area	Material Type	Estimated In-Situ Quantities (CY)	Estimated Quantities Available for Construction[1] (CY)
Area A within spillway excavation	Temblor Sandstone	2,450,000	2,820,000
Area B1 - Hill 1000	Temblor Sandstone	1,600,000	1,840,000
Area B2 - Hill 1000	Blueschist/Graywacke	2,200,000	2,860,000
Area C1	Colluvium	140,000	125,000
Area D	Colluvium	160,000	145,000
Area E - South End of Reservoir	Alluvium	> 2,000,000	> 1,800,000
Existing Embankment	Riprap	-----	24,000
	Random Rockfill	-----	168,000
	Blueschist Rockfill	-----	135,000

[1] Bulking factors: Temblor Sandstone=1.15; rockfill/riprap=1.3; Shrinkage factor: colluvium/alluvium = 0.9

7.6.4 Staging Areas

Construction staging areas would be required for the contractor's and owner/engineer's office trailers, site laboratory, equipment and maintenance yards, and stockpiles for imported filter, drain and aggregate materials. Three staging areas are proposed, as shown on Figure 7-1. One would be located on the saddle at the junction of Calaveras Road and the dam access road, northwest of the reservoir, totaling approximately 50 acres. The second staging area would be located north of the dam on a saddle that overlaps a portion of Borrow Area C, totaling 15 to 20 acres. The third staging area, covering approximately 20 acres, would be located on the topographic bench where the reservoir keeper's house and other buildings are located, immediately south of the Dam. These areas were selected because they are in the vicinity of the dam site and are relatively flat, although some grading may be required.

7.6.5 Imported Materials/Commercial Sources

Commercial sources would provide filter and drain materials. Riprap bedding material would also be provided from commercial sources if not produced from Borrow Area B2. Information was gathered from eight potential commercial sources for these materials that are located within a 75-mile radius of the site. A source survey was prepared and sent to each potential commercial supplier. The survey included preliminary gradation and soundness requirements for filter, drain, and riprap bedding materials. Suppliers were asked whether they could supply the specified quality and quantity of the materials and were also asked to provide information on cost, production capacity, and lead-time requirements. In addition to filling out the survey, suppliers were asked to provide quality control data sheets for all materials. A summary of the information is included in the Commercial Materials Source Assessment (URS, 2005e).

7.6.6 Handling of Water

Water will seep into the dam foundation area during excavation and will require control and handling during excavation, grouting, foundation cleanup and treatment, and initial embankment fill operations. A series of dewatering wells, well points, and/or seepage collection trenches would be used to collect and control seepage at the downstream toe of the cofferdam. Seepage within the dam foundation area would be controlled by sumps and wells. The management, monitoring, and discharge of water associated with construction activities will require a National Pollution Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction Activities, which is issued by the State Water Resources Control Board. The permit includes discharge requirements for nonstorm water generated by construction activities. Seepage that is collected would be pumped to a retention structure and then either pumped back into Calaveras Reservoir or released down Calaveras Creek. Restrictions for discharges into Calaveras Creek must meet basin standards set forth by the Regional Water Quality Control Board (RWQCB) before discharge to the creek.

7.6.7 Calaveras Road Closure and Improvements

Traffic disruption along Calaveras Road would occur during construction. Much of Calaveras Road between Geary Road and Felter Road (Figure 2-1) is one lane and experiences a low volume of vehicular traffic. This section of roadway could be utilized as a major hauling route for imported materials used in dam construction. Due to safety considerations, the section of Calaveras Road between Geary Road and Felter Road may need to be closed to the public for the duration of construction. Coordination of closure of this road will be needed with the California Highway Patrol and Alameda and Santa Clara counties. However, this road segment will need to remain open to emergency vehicles.

Construction traffic on Calaveras Road between Geary Road and the dam access road would require improvements to the existing road. Potential improvements would include increasing the radius of some turns and widening the road to allow large construction vehicles to navigate this section.

7.7 ANCILLARY FEATURES

Water discharged from Calaveras Reservoir for delivery to the SVWTP is pretreated with potassium permanganate at a facility (constructed in 1999-2000) located immediately downstream from Calaveras Dam. It consists of a metal paneled building on a concrete slab approximately 37 feet long by 23 feet wide with chemical feed equipment and storage. It is expected that this facility would need to be demolished and a replacement constructed further downstream.

The SFPUC has recently installed a hypolimnetic oxygen system (HOS) to improve the dissolved oxygen level within the reservoir hypolimnion. The system includes a tank for liquid oxygen storage located on an existing bench and road turnaround immediately to the north of the existing spillway crest. The oxygen is conveyed by HDPE pipe to two 1000-foot-long diffusers located at approximate elevations 615 (approximately 1,500 feet from the dam) and elevation 635 near the Arroyo Hondo arm (approximately 6,500 feet from the dam). Although dam construction is not planned for this area of the reservoir site, it will require that access be maintained for truck deliveries during and following construction of the downstream replacement dam. If the oxygen system successfully improves the quality of the water in the lower levels of the reservoir, the need for the potassium permanganate facility may be reduced or possibly eliminated

7.8 OUTLINE SPECIFICATIONS

Technical specifications describing the scope, product requirements, and procedural requirements for each part of the project would be developed during final design. The technical specifications should follow the Construction Specifications Institute (CSI) format. Under the CSI format, specification sections are divided into three principal parts as follows:

- Part 1 General
- Part 2 Products
- Part 3 Execution

A technical specification outline is included in Appendix E, which shows the types of information that may be included within each of the principal parts.

A table of contents for the technical specifications including the scope of each specification section was developed based on the conceptual design. The table of contents is shown in Appendix E; it will be updated during final design.

7.9 SUMMARY OF OPERATION AND MAINTENANCE PROGRAM

Operation and maintenance of the dam and appurtenant structures will include the following activities:

- Dam Safety:
  - Overall dam safety management program
  - Scheduled (routine) inspections utilizing a “Dam Safety Inspection Checklist”
  - Special inspections following extraordinary events (earthquakes, major spillway operation or abnormal seepage)
  - Maintenance of instrumentation system
- Dam Embankment and Spillway:
  - Dam face vegetation control
  - Repair of grass cover and erosion rills on downstream face of dam
  - Periodic maintenance to replace dislodged riprap on upstream face of dam
  - Debris removal from the upstream side of the dam and spillway
  - Rodent control program
  - Monitoring of slide conditions (downstream of the stilling basin and stabilized slide at dam site)

- Outlet Works:
  - Emergency power supply maintenance
  - Regular valve maintenance and exercise, and demonstration of release facilities operability
  - Intake tower elevator/hoist maintenance
  - Intake tower moisture and gas management
  - Intake (fish) screens maintenance
- Drainage system maintenance
- Access road maintenance
- Maintenance of stream channel including annual inspections and special inspections following periods of heavy spillway discharges
- Maintenance of environmental mitigation.

In addition to the dam site facilities, reservoir water quality management and other applicable programs from SFPUC's Alameda Watershed Management Plan will be required.

KEY POINTS

- Potential biological, cultural, traffic, and water quality considerations associated with the Calaveras Dam Replacement Project were evaluated.
- The proposed project would affect special status species, sensitive habitats, wetlands and waters regulated by federal and state laws.
- Sensitive cultural resources that may be affected by the project include historic and prehistoric features that are regulated by federal and state laws. A number of known cultural resource sites are recorded in the project area. Unrecorded observations of prehistoric resources were also documented during construction of the existing dam.
- To the extent practical, potential impacts were avoided and/or minimized as replacement dam conceptual designs were developed and evaluated.
- Formal evaluations of impacts associated with the construction will have to be completed, and mitigation measures that would satisfy regulatory requirements will have to be developed and included in the project.

8.1 GENERAL

This section describes potential biological, cultural, traffic and water quality considerations associated with the Calaveras Dam Replacement Project that have been previously evaluated in the Task 8 technical memorandum prepared by URS (2005f). Project components that have been evaluated include the dam and spillway, construction staging areas, borrow areas, disposal areas, haul roads, and Calaveras Road improvements.

The discussion of environmental considerations presented below is organized by resource type and project component.

8.2 BIOLOGICAL RESOURCES

Biological resource considerations associated with the dam replacement project would include impacts to species listed under the federal or California endangered species acts, other special status species regulated under the California Fish and Game Code or typically addressed under the California Environmental Quality Act, wetlands or other waters regulated by the federal Clean Water Act, and sensitive natural communities regulated under the California Fish and Game Code (e.g., Section 1600). Special status species with the potential to occur in the project area are listed in Appendix C. The project would potentially require permits or other compliance with the following laws and regulations:

- Federal Clean Water Act (Sections 404 and 401)
- Federal Endangered Species Act
- California Endangered Species Act
- California Fish and Game Code (Section 1600)
- California Fish and Game Code (Sections 4700, 5050, and 5515).

Appendix C lists the special status species with potential to occur in the project vicinity. Figure 8-1 shows special status species habitats and known occurrences of special status species in the study area. Most of the special status species considerations for the proposed project are related to habitats and occurrences of the following species.

KEY POTENTIAL SPECIAL STATUS SPECIES THAT MAY BE IN PROJECT AREA:

- **Rainbow trout resident in the reservoir and spawning in Arroyo Hondo** - The resident rainbow trout population is proposed for listing as threatened under the federal Endangered Species Act.
- **Sacramento perch** - Calaveras Reservoir supports one of the two known natural occurrences of this fish species in California.
- **Pacific lamprey** - Pacific lamprey were petitioned for listing but the petition was denied in January 2005. Pacific lamprey have been documented from Alameda Creek near the confluence of Calaveras Creek.
- **Alameda whipsnake** - This snake species is listed as threatened under the federal Endangered Species Act and core habitat is widespread in the Calaveras Reservoir watershed.
- **California red-legged frog** - This frog species is listed as threatened under the federal Endangered Species Act and is believed to occupy many of the streams that drain into the reservoir as well as Calaveras Creek, downstream of the existing dam.
- **Foothill yellow-legged frog** - This frog species is not listed but would qualify for consideration under the California Environmental Quality Act. Several occurrences are documented in the project area and vicinity.
- **California tiger salamander** - This amphibian was listed as threatened under the federal Endangered Species Act in August 2004. The species breeds in stock ponds within the Calaveras Reservoir watershed.
- **The most beautiful jewelflower** - This rare plant is not listed but would qualify for consideration under the California Environmental Quality Act. Several occurrences are documented in the project area and vicinity.

The following sections summarize the potential biological resource considerations associated with each of the project components. The locations of the project components are shown on Figure 7-1.

8.2.1 Dam Site, Staging Areas, and Spillway

Construction of the replacement dam would affect an undeveloped area that includes grassland, rock outcrops, woodland, and riparian vegetation. The upland habitats are potentially utilized by the Alameda whipsnake. Spillway excavation will affect woodland habitats on the north-facing side of Observation Hill, which may be potentially utilized by the Alameda whipsnake. Temporary haul roads that would be constructed on the south-facing side of Observation Hill for the spillway excavation may affect serpentine grassland habitats that may be suitable for the most beautiful jewel flower. The riparian and wetland habitats along Calaveras Creek are potentially utilized by the California red-legged frog, the foothill yellow-legged frog, and the Pacific lamprey. The staging area south of the existing dam could affect serpentine soil areas that support a known occurrence of the most beautiful jewel flower and may support the host plant of the Bay checkerspot butterfly (CDFG, 2004).

8.2.2 Borrow Areas

Borrow Area A, B, C, and D would affect grassland, woodland, and Diablan sage scrub habitats potentially utilized by the Alameda whipsnake. Sage scrub habitat on the east-facing slopes of Borrow Area B are typical of sites known to support Alameda whipsnake. Adjacent grasslands may be utilized as movement or migration corridors.

Borrow Area E would affect upland habitats between two seasonal streams. Upland habitats may be utilized by aestivating[14] and migrating California tiger salamanders if adjacent ponds provide suitable breeding habitat (Figure 8-1).

8.2.3 Disposal Areas

Several disposal areas (shown on Figure 7-1) have been evaluated (see Table 7-5). Biological resource considerations for the disposal sites include the placement of permanent or temporary fill within wetlands or other jurisdictional waters of the U.S. and impacts to special status species. Federal regulations require the U.S. Army Corps of Engineers to permit the "least environmentally damaging practicable alternative" referred to as the LEDPA. The volume of waste material (unsuitable and excess soil and/or rock materials for use in the dam) that would be generated by the Calaveras Dam Replacement Project would require careful consideration of disposal site alternatives, the potential effects on wetlands or other waters of the U.S., and the practicability of the alternatives. Practicability is the ability to implement the alternative when non-environmental factors such as cost and logistics are considered. Therefore, alternatives that require longer and more costly transport distances, or result in logistical constraints due to construction sequencing may not be considered practicable and would not be considered the LEDPA.

Disposal Area 1 is within and adjacent to oak woodland and serpentine grassland communities that provide habitat for the Alameda whipsnake, the most beautiful jewelflower and the Bay checkerspot butterfly. Habitats for all three species are likely to be impacted by excavation and other construction related activities at this site.

Disposal Area 2, located between the existing dam and the proposed replacement dam, biological impacts include the same potential impacts as the dam site construction (removal of both Alameda whipsnake habitat, and riparian vegetation on Calaveras Creek that is occupied by foothill yellow-legged frog, and potentially Pacific lamprey).

---

[14] **Aestivating:** Many amphibians and some reptiles are only active during the winter wet season. During the summer these species become dormant in small mammal burrows and rock crevices much like animals that hibernate in the winter. Aestivation describes this state of reduced activity or dormancy during the summer season.

Disposal Area 3 would affect previously inundated areas between the current maximum restricted water surface elevation of 705 feet and the original reservoir water surface elevation of 756 feet. Impacts within this elevation range are addressed in the discussion of the inundation area in Section 8.2.6. Above the 756-foot contour, this disposal area would affect wetland, riparian and stream habitats that are potentially occupied by both the foothill yellow-legged frog and the California red-legged frog. Disposal of materials above the 756-foot contour may also affect shrub and grassland habitats that are occupied by the Alameda whipsnake. Impacts to resident fish populations are not anticipated since the disposal site is above the currently reduced water elevation in the reservoir.

Disposal Area 4 would potentially impact vegetation communities that include oak woodlands and annual grasslands. Sensitive species potentially impacted at the site are the Callipe butterfly, Bay checkerspot butterfly, and the most beautiful jewelflower. Oak woodlands at the site also provide suitable movement habitat for the Alameda whipsnake. Known occurrences of the most beautiful jewelflower are located adjacent to the disposal area boundary, and known Bay Checkerspot butterfly habitat occurs within and adjacent to the site.

Disposal Area 5, located where Calaveras Creek enters the upper end of the reservoir, is between the current restricted water surface and the area inundated by the original 756-foot reservoir elevation. No impacts to fish species are expected for this disposal site, however, excavation and construction related activities at this site may impact upland and aquatic habitats utilized by the foothill yellow-legged frog and the California red-legged frog.

8.2.4 Haul Roads

The Borrow Area E haul road would temporarily remove scrub, woodland, and grassland habitat potentially utilized by the Alameda whipsnake and could also result in mortality of snakes that move across the road during construction. The temporary bridge across Arroyo Hondo could affect habitat utilized by the resident rainbow trout due to degradation of water quality during construction. Several segments of the Borrow Area E haul road would consist of improvements to existing dirt roads. One segment approximately 0.5-mile south of the dam bisects a known occurrence of the most beautiful jewelflower and serpentine grasslands that provide potential habitat for the Bay checkerspot butterfly (Figure 8-1). The occurrence of jewelflower consists of several hundred plants that could be adversely affected if the road is widened or if improvements facilitated the introduction of non-native species.

8.2.5 Calaveras Road Improvements

Proposed road improvements could potentially affect chaparral and woodland habitats utilized by the Alameda whipsnake and serpentine soil areas where there are known occurrences of the most beautiful jewelflower. Changes to stream crossings could affect habitats utilized by foothill yellow-legged frog and the California red-legged frog. Bay checkerspot butterfly habitat has also been documented in the vicinity of this segment of Calaveras Road.

8.2.6 Inundation Area

The replacement dam alternative would inundate 606 acres of ruderal plant communities and wildlife habitats that have become established between the original water surface elevation of

756 feet and the current restricted water surface elevation of 705 feet. Plant communities in the recently exposed areas are dominated by herbaceous non-native plant species that have become established since the water was lowered in 2001. The replacement dam alternative would not substantially change the amount of terrestrial wildlife habitat adjacent to the reservoir. However, some of the stream and shoreline areas below the 756-foot contour may be utilized by the California red-legged frog, the foothill yellow-legged frog or the Alameda whipsnake. The restoration of the original lake volume would improve habitat conditions for rainbow trout and Sacramento perch as well as other fish populations in the reservoir compared to current conditions.

8.3 CULTURAL CONSIDERATIONS

KEY TYPES OF CULTURAL RESOURCES THAT ARE IN PROJECT AREA:

- **Existing Calaveras Dam and Appurtenant Facilities** - These facilities are over 50 years old.
- **Known Historic Archaeological Sites** - These sites are related to Euro-American occupation and/or land use activities.
- **Known Prehistoric Archaeological Sites** - These sites are related to Native American occupation and/or land use activities.
- **Unknown Historic and Prehistoric Archeological Sites Area** - These sites are likely.

Cultural resource considerations associated with the dam replacement project would include impacts to known and/or potential “historical resources” regulated under the California Environmental Quality Act, or “historic properties” regulated by the federal National Historic Preservation Act. These resources encompass a variety of types of remains of human activity, including the existing dam, historic buildings on the property, historic archaeological deposits, and prehistoric archaeological sites. The project would potentially require permits or other compliance with the following laws and regulations:

- Federal Clean Water Act (Sections 404 and 401) - this would necessitate compliance with Section 106 of the National Historic Preservation Act (36 CFR 800)
- Lead Agency (San Francisco Planning Department, Major Environmental Analysis Division) enforcement of EIR mitigation measures - this would involve the California Environmental Quality Act; Guidelines section 15064.5.

The following subsections summarize the potential cultural considerations associated with each of the project components. The locations of the project components are shown on Figure 7-1. Figure 8-2 shows areas of cultural resource sensitivity in the study area.

8.3.1 Dam Site, Staging Areas, and Spillway

There are no known ethnographic or archaeological resources that would be affected by the footprint of the replacement dam. A formal evaluation would be needed to assess the significance of cultural resources, if present. There are reports of a prehistoric site with human burials of unknown location that were found during construction of the original dam. It is possible remnants of the site are within the footprint of the dam. The replacement dam would entail either direct effects related to ultimate inundation or alteration of setting to built environment resources. Specifically the known built environment resources that would be affected by the new replacement dam include:

- Calaveras Dam (AW-45)
- Calaveras Dam Spillway (AW-41)
- Calaveras Dam Bridge Over Spillway (AW-43)
- Blue Stone House (AW-42)
- Calaveras Reservoir Intake Tower (AW-44)
- Calaveras Filtration Plant Complex (AW-46)
- CR #3: mine adit (P-01-010674)

No cultural resources have been identified with associated staging areas. The proposed dam site staging areas do not appear sensitive for potential archaeological resources. The staging areas would not directly affect built environment resources (except where the staging areas coincide with the footprint of areas of disturbance associated with construction). It is unlikely there would be short-term effects to built environment resources from the work areas. Pending formal evaluation of these built environment resources, the exact nature and degree of impacts may or may not be significant.

8.3.2 Borrow Sites

In general, the northern borrow areas (Borrow Areas A to D) have a low potential for archeological or built environment resources with the sole exception of two historic archaeological sites recorded on Observation Hill (Borrow Areas B and D). The two sites are CR#1: rock foundation, and CR#2: scattered construction debris possibly associated with construction of the existing dam. It appears CR#1 and CR#2 are located near the east margin of the proposed area and may actually be located in the staging area. It appears that direct impacts to these sites could be avoided.

The south end borrow location (Borrow Area E) would potentially affect site locations AW-66 and -67 and historic site CR#12. Pending formal evaluation of these cultural resources, the exact nature and degree of impacts may or may not be significant. Based on the current configuration of the borrow location, it appears AW67 and CR#1 could be avoided.

8.3.3 Disposal Sites

Disposal Area 1 does not contain any known cultural resources (buildings, structures, or archaeological sites). However, the area has not been subject to a formal cultural resources survey. The area of more moderate relief within the area footprint is considered to have a low sensitivity for archaeological resources. Just outside of the area to the south, there are an historic rock wall and artifact scatter (CR#1 and CR#2).

Disposal Area 2, located between the existing dam and the proposed replacement dam, include the same potential impacts as the dam site construction described in Section 8.3.1.

Disposal Area 3 is located within a currently submerged drainage that appears to have a high potential for prehistoric archaeological resources as such sites are frequently associated with drainage locations. There are also reports of a prehistoric site with human burials of unknown location that were found during construction of the original dam. It is possible remnants of the site are within the footprint of Disposal Area 3. There are also reported homestead locations that may have been within the footprint of Disposal Area 3. It is possible there is a historic archaeological component associated with these homesteads.

Disposal Area 4 encompasses the location of the Calaveras Dam watershed keeper's complex (site AW47). Pending formal evaluation this complex might be found to be a significant cultural resource. The area is considered to have a low sensitivity for prehistoric archaeological resources.

Disposal Area 5 encompasses several homestead locations that may have an archaeological component that, if present, could be affected by use of this location. There are no recorded archaeological sites within the footprint of this area. However, pending formal cultural resource surveys, such sites might be found in the area. The area appears to be sensitive for its potential to contain both prehistoric and historic archaeological sites.

8.3.4 Haul Roads

Much of the existing road network in the Calaveras Reservoir study area constructed in the 1920s as part of the dam project is a potential historic resource (including Calaveras Road), and would need to be evaluated for significance prior to project activities.

The Borrow Area E haul road has the potential to intersect site CR#12. It is likely the road could be engineered to avoid this resource. In the event a site could not be avoided, it would need to be evaluated and if found to be significant subjected to treatment measures such as data recovery, enhanced recordation, archival research, interpretation and other measures as appropriate. Pending formal evaluation of these cultural resources, the exact nature and degree of impacts may or may not be significant.

8.3.5 Calaveras Road Improvements

In general, the potential road improvement area along Calaveras Road traverses an area of relatively low sensitivity for cultural resources. However, Calaveras Road crosses several drainages in this segment that have fairly steep gradients. Based on information developed thus far, drainages in the project area appear to have a greater sensitivity for prehistoric archaeological sites. However, the potential for such resources at these stream crossings is not as high because of the relatively steep gradients of the channels compared to sites where prehistoric archeological sites have been observed elsewhere in the watershed.

8.3.6 Inundation Area

Prehistoric sites CR#8 and 10 would be at least in part affected by the impoundment of reservoir water up to the 756-foot elevation. While mitigation through data recovery, enhanced recordation of built environment features utilizing Historic American Build Survey (HABS)/Historic American Engineer (HAER) standards, archival research, oral histories and on/off-site interpretation could be used to reduce the level of impact, it is not possible at this time to assess whether such measures would reduce impacts to a less than significant level. It is possible that one or more of the prehistoric archeological sites identified during the 2004 reconnaissance may contain substantive subsurface cultural deposits. Until formal testing programs are initiated at these sites, the nature and degree of mitigation cannot be determined. Such sites were identified both along the Arroyo Hondo drainage and the western side of the current restricted reservoir pool.

8.4 CONSTRUCTION TRAFFIC AND ROAD CLOSURE

Due to safety considerations, the section of Calaveras Road between Geary Road and Felter Road may need to be closed to the public for the duration of construction. as discussed in Section 7.6.7. The proposed closure would eliminate through traffic during the construction period, but would allow access to Sunol Regional Wilderness via Calaveras Road and Geary Road from the north. Emergency vehicles would still have access to temporarily closed roads.

Limited traffic surveys show that Calaveras Road currently supports small weekday morning and evening peaks in traffic, suggesting that motorists may be using the route as an alternate to I-680. If the road were closed, this traffic, which averages approximately 250 vehicles per day in each direction, would need to divert to I-680 for north and southbound travel. Motorists seeking access to Sunol Regional Wilderness from the south (e.g., Milpitas and San Jose) would need to use alternate routes, such as taking I-680 to Sunol and traveling south to the park entrance via Calaveras Road. Similarly, motorists in the north attempting to access areas south of Calaveras Reservoir would need to travel south on I-680 to Milpitas and travel east on Calaveras Road.

I-680 is a six- to eight-lane freeway providing regional access between its junction with I-280 and U.S. 101 near downtown San Jose through the East Bay to its junction with I-80 in Fairfield. Recent traffic studies showed that traffic volumes on I-680 in the Milpitas area carries nearly 7,000 vehicles per hour at peak hour (Federal Transit Administration 2004). Assuming all vehicles that would travel on Calaveras Road during peak hour need to travel on I-680, this would add between 100 and less than 200 vehicles to the existing volumes on I-680. This is a small increase that would not measurably degrade levels of service on I-680. By closing a portion of Calaveras Road and using local borrow areas for fill material, truck traffic would be limited to the local construction area and would eliminate having a large number of trucks and passenger vehicles on the road simultaneously. There would still be increased truck traffic on the northern portion of Calaveras Road with trucks bringing aggregate material from the Sunol area.

8.5 WATER QUALITY

Five potential borrow areas have been identified that could be used to construct the replacement dam alternative under consideration by the SFPUC. Of these, four (Borrow Areas A to D) are located essentially downstream of Calaveras Dam and one (Borrow Area E) is upstream of the dam. Excavation during construction would expose soils and increase the potential for erosion during storm events, subsequently increasing suspended sediments in the watershed downstream of the borrow sites.

Soils eroded from Borrow Areas B and C could flow downstream into Calaveras Creek or directly into Alameda Creek, thus affecting water quality in these downstream areas. Soils eroded from portions of Borrow Areas A and D north of the ridgeline could flow into Calaveras Creek and/or Alameda Creek. Sediments from portions of these borrow areas south of the ridgeline would flow into Calaveras Reservoir and would not directly affect Calaveras or Alameda Creeks. Any sediments from Borrow Area E would flow into Calaveras Reservoir and would not affect downstream water quality because the sediment would be trapped within the reservoir.

The erosion potential of the different borrow areas varies based on the type of material in each of these locations. Borrow Areas A and B would have lower potential than Areas C, D, and E due to the type of rock materials at these locations. Topsoil would need to be removed at all locations, and this material is expected to have similar erosion potential at all locations.

Best Management Practices (BMPs) for erosion control would need to be used diligently at all locations, but in particular, those borrow areas located downstream of Calaveras Dam. Standard BMPs for erosion control include measures such as the use of straw bales, silt fences, directing runoff into constructed settling basins, covering stockpiled soils, and locating stockpiled soils away from drainage areas. These measures would be specific to the situation and location, and would be designed in detail during preparation of the Stormwater Pollution Prevention Plan (SWPPP) that will be required prior to the start of construction.

Borrow Areas B and C would have the highest potential to affect downstream water quality due to their proximity to Calaveras and Alameda creeks. Once topsoil is removed, Borrow Area B, which would be excavated into sandstone and blueschist bedrock, may affect water quality less than Borrow Area C, although Borrow Area B is closer to Calaveras Creek. Borrow Area E would have the lowest potential for downstream water quality effects and would not directly affect Calaveras Creek or Alameda Creek because sediments from this location would enter the reservoir and settle out of the water column. It will be important to diligently apply erosion control BMPs during construction in the rainy season and conduct restoration of all borrow areas once excavation in an area is completed.

KEY POINTS

- Based on the conceptual design completed (10 percent design), the costs for the project were estimated.
- The estimated construction cost is $143,780,000 (4th quarter 2005 dollars). The total estimated Project Budget, escalated to the midpoint of construction, would be $272,595,000. Besides the construction cost, the Project Budget includes construction contingency, environmental mitigation costs, and project delivery costs.
- Operation and maintenance costs would be similar to those for the existing dam.

9.1 GENERAL

Costs for a facility can be evaluated based on *capital costs* and *life cycle costs*. *Capital costs* are those associated with initial project development and include construction, construction contingency, environmental mitigation costs, and project delivery costs. *Life cycle costs* are estimated by adding the capital costs to the present value of operation and maintenance (O&M) costs, future repair costs and subtracting salvage value (if any). In general for dams, the most significant costs are those associated with initial capital costs. The estimation of capital costs and life cycle costs are discussed in the following sections.

9.2 CAPITAL COST

The capital cost or project cost estimate is made up of the following costs and allowances:

- Construction cost;
- Construction contingency;
- Environmental mitigation costs; and
- Project delivery costs.

The project cost estimate is summarized in Table 9-1 and presents the estimated amounts for the above elements. The construction cost includes a 30 percent design contingency and represents the estimated construction contract cost (Engineer's Class 4 Dam Construction Cost Estimate). Pricing in this CER was estimated in 4th quarter 2005 U.S. dollars. Pricing at the midpoint of construction (see Section 10) is also shown in Table 9-1. Each of the costs and allowances of the project cost estimate are further discussed in the following sections.

Table 9-1
Project Cost Estimate Summary

Cost Component	Cost
Construction Cost Raw Estimate (4th quarter 2005 dollars)[1]	$110,600,000
Design Contingency/Unlisted Items Allowance (30%)	$33,180,000
Estimated Replacement Dam Construction Cost (4th quarter 2005 dollars)	**$143,780,000**
Construction Cost Escalation[2]	$31,449,000
Base Bid Construction Budget (midpoint of construction)	**$175,229,000**
Construction Phase Contingency (10%)[3]	$17,523,000
Subtotal Construction Cost	$192,752,000
Environmental Mitigation Costs[2]	$11,980,000
Art Commission Fees[2]	$400,000
Total Construction Cost	**$205,132,000**
Project Delivery Cost[2,4]	$67,463,000
Total Project Budget	**$272,595,000**

1. Engineer's Class 4 construction cost estimate for dam and hydraulic structures (see Appendix F).
2. Costs from *Draft Report, Water System Improvement Program Assessment*, by Parsons and CH2M Hill, October 2005.
3. Allowance for costs that may occur during construction.
4. Project Delivery Cost includes the following (percentages based on Subtotal Construction Cost): Program Management: 2%; Project Management: 4%; Pre-design Planning: 2%; Environmental Planning and Review: 2%; Engineering Design Fees: 12%; Construction Management and Contract Admin: 12%; and Department and Agency Fees: 1%.

9.2.1 Construction Cost

The construction cost estimate is a Class 4 estimate as described by the Association for the Advancement of Cost Engineering (AACE, 1998). For the purpose of developing and presenting this conceptual-level construction cost estimate, the work was divided into the following five major elements for the dam and appurtenant works:

- General Requirements
- Site Preparation
- Dam Foundation
- Embankment
- Hydraulic Structures

The major elements are defined based on the design presented in Section 7. Each of the work elements was subdivided along activity levels that can be identified, managed and controlled. A description of each of these elements and back-up and breakdown of these elements for the cost estimate is included in Appendix F. The breakdown shows the estimated direct and indirect costs for each of the activity levels under the major elements of the work. The cost breakdown includes the quantity of work; labor, equipment, material and other costs estimated for each item; and the indirect general and administrative costs (G&A), profit, and bond costs used to arrive at total and unit costs.

9.2.2 Design Contingency

A conceptual design has unlisted items, quantities, requirements and constraints that have not been fully identified, or else are not fully investigated or designed. In later stages of design, the scope of the project also tends to expand as more detail is developed and as regulatory agencies undertake more detailed reviews.

A design contingency is, therefore, incorporated into and becomes an integral part of the estimated construction cost to accommodate those features of the work that cannot be adequately assessed due to the partially developed design. The amount of contingency reflects both the degree of risk associated with uncertainties, particularly with respect to geotechnical conditions, and the completeness of the design detail for the major elements of work. The design contingency is based on, and added to, the subtotal of construction costs because it represents an unknown portion of the total estimated construction cost. The contingency will decrease as the project moves forward into final design as more information becomes available, project requirements become better defined, and more of the design detail is captured in the subtotal of construction costs.

During preparation of this estimate, the potential risks associated with several major constructability issues were considered that include surface and groundwater management, borrow area development, material processing and haul distances, foundation conditions and extent of grout curtain/cutoff wall construction. A 30 percent design contingency was used for a conceptual-level estimate. This percentage is typically used for concept/planning-level dam construction cost estimates.

9.2.3 Construction Contingency

A construction growth contingency should be planned to pay for the cost of owner-directed changes after the project is under contract, changed conditions that occur or are encountered during construction, and other unforeseen conditions or changes. Construction growth costs are often associated with unexpected, or variations in expected, subsurface conditions. An overall construction contingency allowance equal to 10 percent of the construction contract cost is recommended and is included in the estimated project cost.

9.2.4 Project Delivery Cost

Project delivery costs are provided in the Draft Report, Water System Improvement Program Assessment (Parsons and CH2M Hill, 2005), and include the following (percentages based on Subtotal Construction Cost):

- Program Management: 2%
- Project Management: 4%

- Pre-design Planning: 2%
- Environmental Planning and Review: 2%
- Engineering Design Fees: 12%
- Construction Management and Contract Admin: 12%
- Department and Agency Fees: 1%

9.2.5 Environmental Mitigation Costs

Environmental mitigation costs are provided in the Draft Report, Water System Improvement Program Assessment (Parsons and CH2M Hill, 2005), in the amount of $11,80,000.

9.3 LIFE CYCLE COSTS

As previously stated, *life cycle costs* are estimated by adding the capital costs to the present value of O&M costs, future repair costs and subtracting salvage value (if any).

The O&M activities described in Section 7.9 are typical for embankment dams and are presently required in varying degrees for the existing dam. It is anticipated that costs associated with the O&M activities for the replacement dam would be similar to the costs presently expended by SFPUC for the existing dam.

KEY POINTS

- The estimated implementation time from initiation of field work for environmental baseline studies to substantial completion of the project is seven years.
- Engineering design, environmental review, and project permitting would be concurrent.
- The Notice to Proceed with construction would be in early 2009 with project completion in mid-2011. The construction notice to proceed in early 2009 is important to provide for single-season embankment fill placement.
- From an engineering and construction standpoint, the project completion date could be accelerated. However, schedule acceleration may be limited by the environmental documentation and review process.

10.1 SUMMARY

An implementation schedule (Figure 10-1) was developed to assist the SFPUC with conceptualizing and planning for the work involved in completing the Calaveras Dam Replacement Project. The schedule is based on an approach where engineering design, environmental review and project permitting would be performed concurrently. This schedule conforms to the Water Supply Improvement Program schedule provided by SFPUC in March 2005 and the most recent Environmental Review schedule.

The schedule shows five main phases of the project, with the involvement of the SFPUC, DSOD, various permitting agencies, along with the environmental, engineering and construction management consultants. Interdependencies of the various phases and the critical path activities are shown on the schedule. The total duration for the project could be on the order of seven years from the start of the field work for the environmental baseline studies. This estimate is dependent on the duration of federal and state permitting processes, which can be difficult to predict.

10.2 CRITICAL PATH ACTIVITIES

The implementation schedule was predicated on achieving a construction notice to proceed (NTP) date at the beginning of 2009, in order to provide the contractor with three full construction seasons in which to complete the work.

The preferred construction schedule is to complete the necessary foundation preparations such that the embankment can be constructed and completed in a single construction (dry) season, which is from about mid-March to mid-December (9 months). It takes about 15 months to complete the necessary foundation preparations (excavation and grouting) in order to start the embankment construction. As such, the NTP for construction should be issued around January or February the year before embankment construction.

A mid-year NTP is considered less desirable because the embankment construction may have to span over two seasons (stop during the wet winter months) that could potentially result in overall longer construction and higher construction costs (see Appendix F).

The critical path activities to achieve a February 2009 NTP run through the environmental baseline studies, the project permitting and agency consultation process, obtaining DSOD's final review and approval to construct, and the bid and award phase. The implementation schedule incorporates an estimate of reasonable time for SFPUC, CTAP, and DSOD review and comment of major deliverables. Final design and project permitting are concurrent activities on this schedule with completion at the same time. The permit completion date of June 2008 is on the critical path. Slippage would jeopardize the DSOD Approval date and the February 2009 Construction NTP. To mitigate against this potential slippage, the option to accelerate the bid and award phase by SFPUC should be considered.

It is noted that the Calaveras Dam Replacement Project is one of the regional projects included in the Water System Improvement Plan (WSIP) Programmatic EIR that is being completed. It is anticipated that the Programmatic EIR will be completed prior to the Project EIR.

10.3 IMPLEMENTATION SCHEDULE

The implementation schedule shows the milestones for (1) environmental review and permitting, (2) design, (3) bid and review, and (4) construction management and construction phases. Environmental baseline studies are currently in progress. The initial CEQA studies and preparation of the first Preliminary Draft of the EIR would be completed in August 2006. Following a 6-month public comment period, comments would be incorporated into a Draft EIR, to be published in February 2007. The Major Environmental Analysis (MEA) Division of the San Francisco Planning Department is scheduled to certify the EIR in December 2007. The Project Permitting and Agency Consultation phase is scheduled to be completed in June 2008. The following milestones are based on SFPUC's most recent schedule for the environmental review and permitting phase for the Calaveras Dam Replacement Project:

• Environmental Application to MEA & NEPA Lead Agency	Nov. 30, 2005
• Completed MEA & NEPA Lead Agency Review of Tech Studies	July 17, 2006
• Preliminary Draft 1 of EIR/NEPA to Lead Agencies for Review	Aug. 16, 2006
• MEA & NEPA Lead Agency Publish Draft EIR/NEPA	Feb. 22, 2007
• MEA Certifies Final EIR	Dec. 13, 2007
• NEPA Lead Agency Publishes Record of Decision	March 12, 2008
• Final EIR/NEPA	April 25, 2008
• Environmental Permits Obtained	June 30, 2008

The first phase of final design would begin in late 2005 with the environmental clearances required to complete an 8-month field investigation program in mid-2006. The design of the field investigation program would avoid and/or minimize to the extent practical the impact on habitat occupied by federally listed species, working in areas that would trigger the Federal Clean Water Act (Section 404 and 401) and riparian/stream areas regulated by the Department of Fish and Game (Section 1600 California Fish and Game Code).

Final design would begin during the field investigation (in January 2006) with the performance of a spillway model study to confirm the final configuration of the spillway and the overall project. Final design and DSOD consultation would run concurrently with the project permitting and agency consultation through the mid-2008 culminating in completion the final design reports and production of the final contract document set (drawings, legal and commercial terms, and technical specifications). SFPUC would begin the selection process for the construction manager, so that the construction manager could provide input to the drawings and specifications at the 65 percent level through completion of design.

Six weeks is provided following completion of the final design for DSOD's final review and obtaining approval to construct. Final approval from DSOD is expected to occur within this time period because they will have been involved in review throughout the various stages of design, and progressing from 95% to 100% design would not involve significant design changes.

Advertisement for construction bids would begin in July 2008 provided DSOD's approval to construct has been obtained and with all the required state and federal agency permits in place. Following a 10-week bid period ending in September 2008, SFPUC would have 20 weeks (4½ months) to review the bids and approve a contract with the successful bidder. Award of the construction contract would be no later than early February 2009 in order to give a construction NTP no later than February 2009.

A conceptual-level construction schedule is discussed in Appendix F. The construction schedule in Appendix F shows 2½-years for substantial completion (beneficial use) of the project based on a February 2009 NTP date. However, for planning purposes, 3 years has been allowed for construction. Substantial completion is shown in mid-2011 at which time SFPUC would be able to use the reservoir facilities.

The following list summarizes the major activity milestones shown on the implementation schedule (Figure 10-1) based on achieving substantial completion of the project in mid-2011:

MAJOR ACTIVITY MILESTONES

• Complete and distribute the Public Draft EIR	February 2007
• MEA Certifies Final EIR	December 2007
• Complete Final Design	May 2008
• Complete Permitting and Agency Consultation	June 2008
• Receive DSOD Approval to Construct	July 2008
• End of 10-week Bid Period	September 2008
• Award Construction Contract	February 2009
• Construction NTP	February 2009
• Substantial Completion of Construction	June 2011

KEY POINTS

- Conceptual engineering and design studies were completed to address alternatives for remediating the existing dam or construction of a new replacement dam and appurtenances to restore the reservoir to its original intended function (with a nominal storage capacity of 96,850 acre-feet).
- Based on the results of an alternatives analysis, the preferred alternative is a replacement earthfill dam located downstream of the existing dam with an open chute spillway. The dam design includes the ability for enlargement for future generations.
- The foundation conditions are acceptable for construction of an earthfill dam and sufficient materials are available on site for the main zones of the dam.
- The project design criteria provide for a robust design that can accommodate Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE) seismic loading conditions.
- A number of biological and cultural resources considerations related to the replacement dam have been identified. To the extent practical, they have been avoided or minimized. Formal evaluations of impacts associated with construction will have to be completed, and mitigation measures that would satisfy regulatory requirements will have to be developed and include in the project.
- Based on the conceptual design completed (10 percent design), the estimated construction cost is $143,780,000 (4th quarter 2005 dollars). The total estimated Project Budget, escalated to the midpoint of construction, would be $272,595,000. Besides the construction cost, the Project Budget includes construction contingency, environmental mitigation costs, and project delivery costs.
- Implementation of the replacement project is estimated to require seven years from initiation of field work for environmental baseline studies to substantial project completion. Construction would commence in early 2009 with project completion in mid-2011. From an engineering and construction standpoint, the project completion date could be accelerated. However, schedule acceleration may be limited by the environmental documentation and review process.
- Final design work will need to include geotechnical investigations in the dam foundation and borrow areas. Also, final design engineering will need to consider optimization in layouts of the foundation and spillway excavations and dam design; spillway hydraulic modeling; materials handling evaluations; foundation seepage control system; and stability and seismic deformation analyses.

11.1 CONCEPTUAL DESIGN

11.1.1 Recommended Project

The 210-foot-high Calaveras Dam was completed in 1925, with a nominal storage capacity of 96,850 acre-feet. In the winter of 2001, in response to concerns of the California Division of

Safety of Dams (DSOD) about the seismic stability of the dam, SFPUC lowered the Calaveras Reservoir to a maximum level corresponding to 38,100 acre-feet, approximately 39 percent of its original maximum capacity. Because of the original hydraulic fill dam construction and the proximity of the dam to the Calaveras fault, strong ground motions generated during a large earthquake on the fault could impact the stability of the existing dam. Conceptual engineering and design studies were initiated to address alternatives for remediating the existing dam or construction of a new replacement or enlarged dam and appurtenances to restore the reservoir to its original intended function or to provide for an enlarged reservoir. Based on the results of an alternatives analysis, the preferred alternative is a replacement earthfill dam located downstream of the existing dam with an open chute spillway. The dam design includes the ability for enlargement for future generations.

The conceptual engineering design for a dam located downstream of the existing Calaveras Dam is presented in this CER. The dam would replace the existing dam and would restore the maximum reservoir level to a pre-2001 DSOD restriction level of elevation 756.2 feet. The recommended Calaveras Dam Replacement Project will include the following:

- Replacement of the existing dam with a new dam located downstream of the existing dam.
- The new dam would have a nominal reservoir storage of 96,850 acre-feet (normal maximum water surface elevation, NMWS, elevation = 756.2 feet).
- The new dam would accommodate enlargement up to 386,000 acre-feet[15] (NMWS elevation = 890 feet[16]).
- The project will include a new or rehabilitated outlet works for seismic safety, improved operations and maintenance, and accommodations for releases for environmental purposes.

One of the design parameters calls for the potential inclusion of the dam in a larger dam in the future. This concept resulted from the realization that costs to achieve this purpose are minimal compared with costs to construct a replacement dam that does not have the ability to be enlarged. In order to address this in the design, an upper limit on the size of a future reservoir had to be identified. Since there is no knowledge of whether there will be a future need for Calaveras Reservoir to be larger than the proposed 96,850 acre-feet (and if there will be a need, what size it would be), an engineering solution to the question of reservoir size was evaluated. It was determined that a reasonable upper limit on the elevation of a future reservoir would be 890 feet, which is the elevation of the Alameda Creek Diversion Tunnel intake. This is the highest reservoir elevation that would not require modification of the diversion facilities. If a reservoir at elevation 890 were to be built in the future, it would have a storage capacity of approximately 386,000 acre-feet.

---

[15] Core and filter dimensions within the new dam will be constructed to accommodate enlargement of the dam to 386,000 acre-feet.

[16] Approximate invert elevation of the Alameda Creek Diversion Tunnel.

11.1.2 Foundation Conditions and Borrow Materials

The foundation conditions are acceptable for construction of an earthfill dam and sufficient materials are available on site for the main zones of the dam. A geotechnical investigation program including field explorations and laboratory testing was conducted to investigate foundation conditions at the dam and availability of materials in borrow areas.

The dam will be founded on the Temblor Sandstone (left abutment of the dam) and the Franciscan Complex (in the valley bottom and right abutment of the dam). The Temblor Sandstone is highly to intensely fractured, with some joints that are as much as 0.5-inches wide. This fractured rock condition causes high hydraulic conductivities (100 to 400 lugeons) in upper 60 to 100 feet of the abutment rock. The Franciscan Complex includes serpentinite and a mélange shale matrix containing hard rock blocks. The serpentinite and mélange shale matrix make up 30 percent of the rock mass in the dam foundation. Hydraulic conductivities in the Franciscan are low to moderate (less than 40 lugeons, and mostly less than 10 lugeons). Excavation depths up to 80 feet are required at the right abutment to remove landslides and weathering rock materials.

Embankment shell materials can be obtained from the spillway excavation/borrow area in the dam site. Core materials can be obtained from a borrow area at the upstream end of the reservoir. Riprap can be produced from an existing on-site hard rock quarry and salvaged from the existing dam. Riprap bedding could be produced from the existing rock quarry or be imported. Filter and drain materials would be imported or may be processed from alluvial fan deposits at the upstream end of the reservoir.

11.1.3 Faults in the Dam Site Vicinity

Besides the active Calaveras fault, faults in the vicinity of the dam site were evaluated according to DSOD criteria. Seven trenches were excavated in the dam site area across the Quarry, Spillway, and Corral Point faults. Detailed mapping of the stratigraphic and structural relations exposed in the walls of the trenches was performed. The activity of the Quarry, Spillway, Gully, and Corral Point faults was assessed based on DSOD guidelines as follows:

- the Quarry and Spillway faults, which are in the dam site, were concluded to be inactive;
- the Gully Fault, located west of the dam site, was considered to be conditionally active; and
- the Corral Point Fault, located south of the dam site, was concluded to be active.

DSOD's concurrence on the conclusion that the Quarry and Spillway faults are inactive provide the basis to develop appropriate design parameters for the replacement dam.

11.1.4 Seismic Ground Motion Parameters

Based on a deterministic approach, seismic ground motions for the dam are based on a Maximum Credible Earthquake (MCE) **M** 7¼ earthquake on the central Calaveras fault at a distance of 0.5 km (0.3 mile) from the dam site. The 84th percentile MCE peak horizontal acceleration was calculated to be 1.1 g. Corresponding ground motions were adjusted for directivity due to the near-field distance between the dam and the Calaveras fault. Reservoir Triggered Seismicity is highly unlikely for the replacement dam.

11.1.5 Replacement Dam

The design criteria for the Calaveras Dam Replacement Project provide for a robust design that can accommodate Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE) seismic loading conditions.

The replacement project would consist of a downstream replacement dam, a curved left abutment spillway, a new or rehabilitated intake tower, and extension of the existing outlet. The downstream replacement dam would be founded on bedrock. Anticipated seepage through the upper high hydraulic conductivity zone in the Temblor Sandstone (left abutment) will be intercepted using a concrete cutoff wall or multi-row grout curtain. A grout curtain would intercept seepage in the Franciscan Complex (valley floor and right abutment).

The existing dam would function as a cofferdam during construction. The reservoir level behind the cofferdam would need to be aggressively operated to maintain and/or restore the reservoir to a level at or below elevation 705.45 during periods of heavy inflows.

Most of the construction materials for the dam can be obtained on site. The shells of the dam would be constructed using Temblor Sandstone generated from the required spillway excavation. Sources of the other borrow materials would be as described in Section 11.1.2. The width of the core of the embankment will be about 76 feet at the top so that the potential for expansion would not be precluded. Seepage through the dam would be controlled by a robust chimney and blanket filter and drain system.

11.1.6 Environmental Considerations

A number of biological and cultural resources considerations related to the replacement dam have been identified. Special status species, cultural resources, and water quality at the site are likely to be affected by construction of the dam. Formal evaluations of impacts associated with construction will have to be completed and mitigation measures that would satisfy regulatory requirements will have to be developed and included in the project.

Due to safety considerations, the section of Calaveras Road between Geary Road and Felter Road may need to be closed to the public for the duration of construction.

11.1.7 Estimated Capital Cost and Project Schedule

Based on the conceptual design completed (10 percent design), the estimated construction cost is $143,780,000 (4th quarter 2005 dollars). The total estimated Project Budget, escalated to the midpoint of construction, would be $272,595,000. Besides the construction cost, the Project Budget includes construction contingency, environmental mitigation costs, and project delivery costs.

Implementation of the replacement project is estimated to require seven years from initiation of field work for environmental baseline studies to substantial project completion. Engineering design, environmental review, and project permitting would be concurrent. The notice to proceed for construction would be in early 2009 with project completion in mid-2011. From an engineering and construction standpoint, the project completion date could be accelerated. However, schedule acceleration may be limited by the environmental documentation and review process.

11.2 RECOMMENDATIONS FOR FINAL DESIGN

11.2.1 Final Design Investigations

For final design, geotechnical investigations will be needed to confirm design assumptions and to refine the design. Additional investigations in the dam and spillway foundation, new intake tower, and borrow areas should be conducted to supplement the data gathered for conceptual engineering. The investigation program should be designed to:

- Obtain additional data to evaluate the required depth and extent of the concrete cutoff or grout curtain in Temblor Sandstone.
- Further characterize the foundation excavation depth required in the Franciscan Complex and Temblor Sandstone.
- Further characterize the extent and depth of the right abutment landslide to evaluate its required treatment.
- Characterize the hydraulic conductivities of the Temblor Sandstone/Franciscan Complex contact.
- Characterize the earthfill properties of the Temblor Sandstone for use as shell zone materials and alluvium in Borrow Area E for use in the core zone.
- Evaluate potential sources of gravels in the vicinity of Borrow Area E.
- Characterize existing dam fill at the downstream toe of the cofferdam.
- Confirm the lateral and vertical extent of hard rock in Borrow Area B.

The geotechnical investigation program would involve similar types of work as were performed for conceptual engineering. These would include the following:

- Field geologic mapping and preparing geologic maps;
- Conducting seismic refraction surveys;
- Drilling bucket auger borings;
- Excavating test pits;
- Drilling rock core borings and conducting packer tests;
- Performing downhole acoustic televiewer and other geophysical logging;
- Performing borehole pressuremeter tests to evaluate rock strength characteristics of the Franciscan mélange.
- Laboratory testing of soil and rock, including triaxial compression tests on recompacted core and shell zone materials and cyclic triaxial tests on compacted shell zone materials; and

- Constructing a test fill for the Temblor Sandstone to evaluate its placement and compaction requirements.
- Performing a test grout section in the Temblor Sandstone to evaluate the effectiveness of grouting this formation for seepage control.

11.2.2 Final Design Engineering

There are a number of challenges that face the final design of the Calaveras Dam Replacement Project. Among these challenges are reduction of the amount of wastage of excavated materials from the left abutment of the dam (Temblor Sandstone) and optimization of the embankment dam zoning. Final design engineering will need to consider layouts of the foundation and spillway excavations; spillway hydraulic modeling; materials handling evaluations; foundation seepage control system; evaluation of updated published ground motions; and stability and seismic deformation analyses.

There are potential areas for optimization during final design that could result in reduced cost and/or environmental impacts. These include the following:

- Evaluate installation of a multi-row grout curtain instead of a concrete cutoff wall to intercept seepage in the Temblor Sandstone;
- Adjustment of spillway alignment closer to the dam to reduce excavation quantities;
- Refine cofferdam geometry to reduce cofferdam excavation.

11.2.3 Path Forward

The Calaveras Dam Replacement Project represents one of SFPUC's largest water system improvement projects. This project has a demanding schedule, to be completed in 2011, or sooner. As such, SFPUC will need to proceed aggressively with both its environmental studies and final design engineering to successfully deliver this project on time and within budget.

Abrahamson, N. (2000). Effects of rupture directivity on probabilistic seismic hazard analysis, Sixth International Conference on Seismic Zonation, v. I, p. 151-156.

Abrahamson, N.A. and Silva, W.J. (1997). Empirical response spectral attenuation relations for shallow crustal earthquakes: Seismological Research Letters, v. 68, p. 94-127.

Association for the Advancement of Cost Engineering International (AACE) (1998). Recommended Practice No. 18R-97, Cost Estimate Classification System, June.

Boore, D.M., Joyner, W.B., and Fumal, T.E. (1997). Equations for estimating horizontal response spectra and peak acceleration from western North American earthquakes: A summary of recent work: Seismological Research Letters, v. 68, p. 128-153.

Calaveras Technical Advisory Panel. (2004b). Report for Meeting No. 2, July 27-29.

Camp Dresser & McKee, Inc./URS (CDM/URS) (2005). Sunol Valley Water Source Reliability Alternatives Analysis Report (Task 10.4), Draft, May 16.

CDFG (California Department of Fish and Game). (2004). California Natural Diversity Data Base (CNDDB). Electronic data provided by the Natural Heritage Division, California Department of Fish and Game, Sacramento, CA.

Division of Safety of Dams (DSOD) (1979). Phase I Inspection Report for Calaveras Dam, National Dam Inspection Program, August.

Division of Safety of Dams (DSOD) (1993). Guidelines for the Design and Construction of Small Embankment Dams, January.

Division of Safety of Dams (DSOD) (2002). Memorandum of Office Conference - Calaveras Dam, No. 10 Alameda County, November 22, 2002: by Wallace Lam, 3 p., plus enclosures.

Fraser, W.A. (2001). Fault activity guidelines of the California Division of Safety of Dams: California Division of Mines and Geology Bulletin 210, p. 319-325.

Fraser, W.A. and Howard, J.K. (2002). Guidelines for use of the consequence - hazard matrix and selection of ground motion parameters: unpublished memorandum, California Division of Safety of Dams, 9 p.

Geomatrix Consultants, Inc. (2002). Geologic mapping and fault evaluation, Calaveras Dam seismic evaluation study: unpublished report to Olivia Chen Consultants, dated October 9, 2002, 11 p.

Kelson, K.I. (2001). Geologic characterization of the Calaveras Fault as a potential seismic source, San Francisco Bay area, California, *in* Ferriz, H. and Anderson, R. (eds.), Engineering Geology Practice in Northern California: Division of Mines and Geology Bulletin 210, Association of Engineering Geologists Special Publication 12, p. 179-192.

Lessman, J. L. (2002). Review of Surface Geologic Mapping for Fault Rupture Hazard Evaluation: Calaveras Dam No. 10.

Natural Resources Conservation Service (NRCS) (2003). United States Department of Agriculture (USDA), Urban Hydrology for Small Watershed - TR 55.

Oppenheimer D.H., and Lindh, A.G. (1992). The potential for earthquake rupture of the northern Calaveras fault: California Division of Mines and Geology Special Publication, v. 113, p. 233-240.

Packer, D.R., Cluff, L.S., Knuepfer, P.L., and Withers, R.J. (1979). Study of reservoir induced seismicity: U.S. Geological Survey Open-File Report 80-1092, 279 p.

Page, B.M. (1982). The Calaveras Fault zone of California, an active plate boundary element, in Hart, E.W., Hirschfeld, S.E., and Schulz, S.S., eds., Proceedings of the Conference on Earthquake Hazards in the Eastern San Francisco Bay Area: California Division of Mines and Geology Special Publication 62, p. 175-184.

Parsons and CH2M Hill (2005). Draft Report, Water System Improvement Program Assessment, prepared for the San Francisco Public Utilities Commission, October.

Sadigh, K., Chang, C.Y., Egan, J.A., Makdisi, F., and Youngs, R.R. (1997). Attenuation relationships for shallow crustal earthquakes based on California strong motion data: Seismological Research Letters, v. 68, p. 180-189.

Simpson, D.W. (1976). Seismicity changes associated with reservoir impounding: Engineering Geology, v. 10, p. 371-385.

Somerville, P.G., Smith, N.F., Graves, R.W., and Abrahamson, N.A. (1997). Modification of empirical strong ground motion attenuation relations to include the amplitude and duration effects of rupture directivity: Seismological Research Letters, v. 68, p. 199-222.

Toppozada, T.R. and Morrison, P.W. (1982). Earthquakes and lake levels at Oroville, California: California Geology, v. 35, p. 115-118.

Uniform Building Code (1997).

URS (2004a). Calaveras Dam Conceptual Engineering, Task 2 - Alternatives Evaluation and General Design Criteria, April.

URS (2004b). Calaveras Dam Conceptual Engineering, Spillway and Outlet Works (Task 7), Draft, July.

URS (2004c). Calaveras Dam Conceptual Engineering, Existing Dam Remediation Alternatives (Task 9.1), Draft, July.

URS (2004d). Calaveras Dam Conceptual Engineering, Evaluation of Replacement and Enlarged Dam Alternatives (Task 9.2), Draft, July.

URS (2004e). Calaveras Dam Conceptual Engineering, Operation of Reservoir/Storage and Bypass Requirements During Construction (Task 11.1), Draft, July.

URS (2004f). Calaveras Test Site Hazardous Waste Evaluation, (Task 5.2), Final, October.

URS (2005a). Calaveras Dam Conceptual Engineering, Geotechnical Data Report (Tasks 4.4 & 5.4), Final, January.

URS (2005b). Calaveras Dam Conceptual Engineering, Geotechnical Interpretive Report (Tasks 4.4 & 5.4), Final, January.

URS (2005c). Seismic Source Characterization and Deterministic Ground Motion Assessment, (Task 6.3), Final, February.

URS (2005d). Calaveras Dam Conceptual Engineering, Cost Estimates of Alternatives (Task 13), Final, March.

URS (2005e). Calaveras Dam Conceptual Engineering, Commercial Materials Source Assessment (Task 5.3), Final, March.

URS (2005f). Calaveras Dam Conceptual Engineering, Environmental Constraints Evaluation of the Proposed Dam Alternatives, (Task 8), Final, March.

URS (2005g). Calaveras Dam Conceptual Engineering, Evaluation of Remediation and Alternatives (Task 9.3), Final, March.

U.S. Army Corps of Engineers (USACE) (1970). Engineering and Design Stability of Earth and Rock-Fill Dams, EM 1110-2-1902, April.

U.S. Army Corps of Engineers, Hydrologic Engineering Center (2003). Hydrologic Modeling System (HEC- HMS), Version 2.2.2, May.

U.S. Department of Commerce (1999). Probable Maximum Precipitation for California, Hydrometeorological Reports No. 58 and 59, February.

U.S. Bureau of Reclamation (1992). Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams.

U. S. Geological Survey (USGS) (1992). National Land Cover Data (NLCD), 30-Meter Resolution Digital Files, Downloaded from http://edc.usgs.gov/ at the EROS Data Center Sioux Falls, SD.

U.S. Weather Bureau (1961, Revised 1969). Interim Report, Probable Maximum Precipitation in California, Hydrometeorological Report No. 36, October.

William Lettis & Associates, Inc./URS (WLA/URS) (2005). Investigation of Fault Rupture Potential at Calaveras Dam (Task 6.2), January 25.

William Lettis & Associates, Inc. (2004). Geologic and Geotechnical Characterization of Proposed Sunol Valley Pipeline Alternatives, Hetch Hetchy Aqueduct, Alameda County, California: Water Infrastructure Partners (in prep).

Wong, I.G. and Strandberg, J.F. (1996). Assessing the potential for triggered seismicity at the Los Vaqueros Reservoir, California, *in* Seismic Design and Performance of Dams, Sixteenth Annual USCOLD Lecture Series, p. 217-231.

Working Group on California Earthquake Probabilities (WGCEP) (1999). Earthquake probabilities in the San Francisco Bay region: 2000 to 2030--A summary of findings: U.S. Geological Survey Open-File Report 99-517.

Working Group on California Earthquake Probabilities (WGCEP) (2003). Earthquake probabilities in the San Francisco Bay region: 2002-2031: U.S. Geological Survey Open-File Report 03-214.

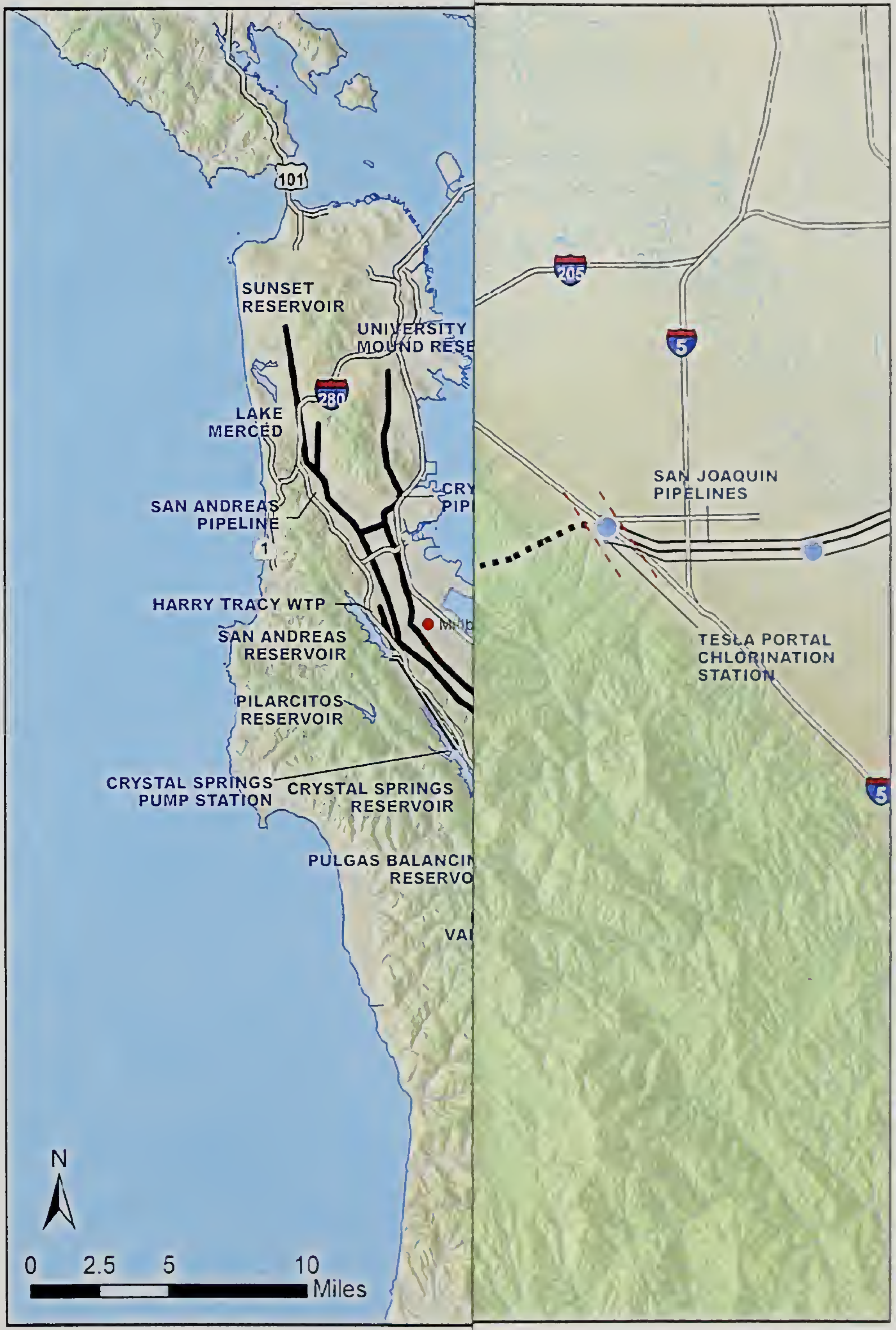
Active fault	(a) A fault on which significant subsurface earthquake activity or any surface ground breakage has occurred in the last 11,000 years. (b) A fault that has the potential for displacement in the present tectonic environment.
Alluvium	A general term for detrital deposits of recent times made by streams on riverbeds, floodplains and alluvial fans.
Amphibolite	A metamorphic rock containing mostly amphibole and plagioclase feldspar.
Anticline	A fold, usually from 100 meter to 300 kilometers in width, that is convex upward with the oldest strata at the center.
Aseismic	Not subject to earthquakes; fault movement that is slow and gradual and does not cause strong ground shaking.
Blueschist	A metamorphic rock formed under condition of high pressure and relatively low temperature, often containing the blue minerals glaucophane and kyanite.
Boulder	Particles of rock that will not pass a 12-inch square opening.
Brecciated	A coarse-grained clastic rock that is composed of angular broken rock fragments held together by a mineral cement or fine-grained matrix.
Calcareous	Containing calcium carbonate.
Calcite	A common rock-forming mineral, CaCO3.
Carbonate	A mineral compound characterized by a fundamental anionic structure of CO3 -2.
Cenozoic	The latest of the four main eras into which geologic time is divided; it extends from the close of the Mesozoic Era, about 65 million years ago, to the present.
Chert	A hard sedimentary rock composed primarily of cryptocrystalline silica.
Clast	An individual constituent, grain or fragment of a sedimentary rock.
Cobble	Particles of rock that will pass a 12-inch square opening and will be retained on a 3-inch sieve.
Colluvium	A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.
Conglomerate	A course-grained, clastic sedimentary rock composed of rounded fragments larger than 2 mm in diameter set in a fine-grained matrix.
Coseismic	Occurring at the same time as an earthquake.
Creep	Slow ground displacement along a fault usually occurring without accompanying earthquakes.
Cretaceous	The final period of the Mesozoic Era thought to have covered the span of time between 144 and 65 million years ago.
Dextral Fault	A right lateral fault (see right lateral).
Dike	A tabular body of igneous rock that cuts across the structure of adjacent rocks or cuts massive rocks.

Dip	The downward inclination of a plane perpendicular to, or nearly perpendicular to, the strike of the strata.
Directivity	An effect during a seismic event whereby an earthquake's energy is directed more strongly in one direction than another.
En-echelon	Geologic features (usually faults) that are in an overlapping or staggered arrangement.
Eocene	An epoch of the Tertiary period (see Tertiary) thought to span 55 to 34 million years before present.
Fault Zone	A zone in which there are a number of more or less closely spaced faults.
Feldspathic	Said of a rock or other mineral aggregate containing feldspar.
Foliation	A planar arrangement of textural or structural features in any type of rock.
Formation	A convenient unit of considerable thickness (from a few meters to several thousand meters) and extent that is used in mapping, describing or interpreting the geology of a region, and the only formal unit that is used for completely dividing the whole geologic column into named units on the basis of lithology (description of rocks).
Fracture	Any break in a rock, whether or not it causes displacement, due to mechanical failure by stress.
Fracture Frequency	The number of naturally occurring fractures in each foot of core; does not include mechanical breaks (induced by drilling) or healed fractures.
Friable	Rocks that are easily crumbled.
Geomorphic	Pertaining to the form of the earth or of its surface features.
Glaucophane	A blue fibrous or prismatic mineral of the amphibole group commonly found in blueschist.
Graben	A depressed block of the Earth's crust that is bounded on all sides by faults, typically normal faults or warps in strike slip faults.
Gravel	Particles of rock that will pass a 3-inch sieve and be retained on a No. 4 sieve.
Graywacke	Dark gray, firmly indurated coarse-grained sandstone that consists of poorly sorted angular to subangular grains of quartz and feldspar, with a variety of dark rock and mineral fragments, embedded in a compact clayey matrix.
Greenstone	A metamorphically altered basic to ultrabasic igneous rock (typically basalt, gabbro, or serpentinite) that owes its greenish color to the presence of chlorite, hornblende, or epidote.
Gypsum	A chemically precipitated sedimentary rock composed of hydrous calcium sulphate.
Holocene	The most recent epoch of geologic time extending from 11,000 years before present to the present.

Hydraulic Conductivity	The rate of flow of water in gallons per day through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature or adjusted for a temperature of 60 degrees Fahrenheit.
Hyetograph	A chart or graphic representation of the average distribution of rain over a given portion of the earth's surface.
Hypolimnion	The bottom waters of a thermally stratified lake.
Inclinometer	An instrument that is used to measure movement of a landslide. Typically involves grouting a longitudinally grooved plastic pipe into a vertical borehole and then periodically lowering a calibrated probe down into the casing along the grooves to measure the tilt of the casing and comparing this tilt to previous readings.
Igneous	Rocks or minerals that solidified from molten or partly molten material.
Interbeds	A bed, typically thin, of one kind of rock material occurring between or alternating with beds of another kind.
Joint	A surface of actual or potential fracture or parting in a rock, without displacement.
Jurassic	The middle of three periods comprising the Mesozoic Era thought to have covered the span of time between 206 and 144 million years ago.
Left abutment	When looking downstream from the dam, this is the valley wall to the left on which the dam is placed
Lineament	A linear topographic feature of regional extent that is believed to reflect crustal structure.
Lithology	(a) The description of rocks. (b) The physical character of a rock.
Lugeon	One lugeon is equal to a water take of 1 liter per minute per meter of test interval at a pressure of 1MPa.
Mélange	A mappable body of rock that includes fragments and blocks of all sizes, both exotic and native, embedded in a fragmented and generally sheared matrix.
Metamorphic rocks	Rocks formed from original igneous or sedimentary rocks through alterations produced by pressure, heat or the infiltration of other materials at depth below the surface zones of weathering and cementation.
Micaceous	Consisting of, containing, or pertaining to mica.
Miocene	An epoch in the early Tertiary period (See Tertiary), between about 24 and 5.3 million years before present, after the Oligocene and before the Pliocene.
Mudstone	The lithified equivalent of mud, a fine-grained sedimentary rock similar to shale but more massive.
Neocene (Neogene)	An interval of time incorporation the Miocene and Pliocene epochs of the Tertiary period. The later Tertiary between 24 and 1.8 million years before present.

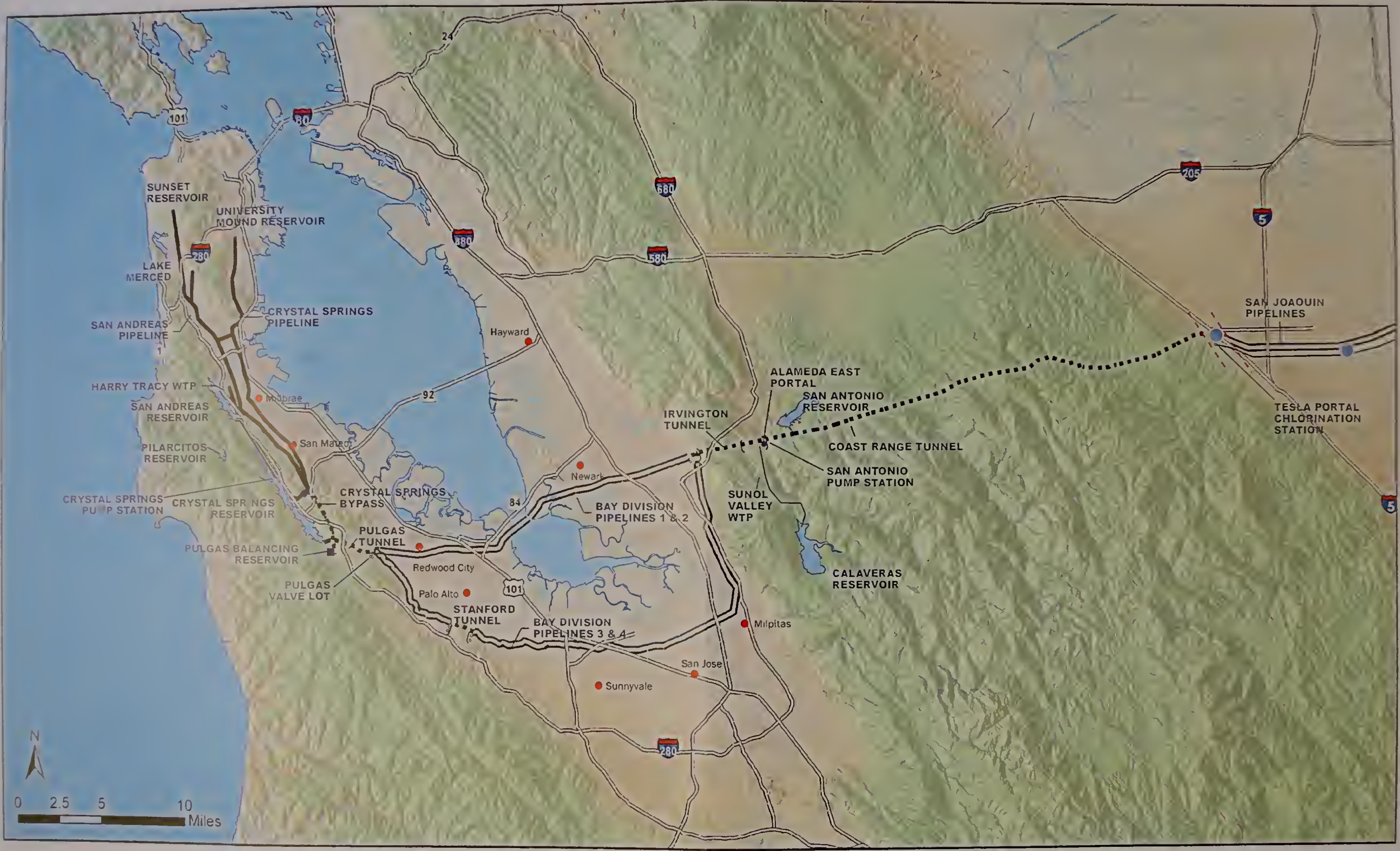
Oblique Normal	A normal fault with some amount of strike slip as well as the predominantly dip slip movement.
Ophiolite	An assemblage of mafic and ultramafic igneous rocks with deep-sea sediments supposedly associated with divergence zones and the sea-floor environment.
Phreatic Surface	The top surface of the groundwater table.
Piezometer	An installation within a borehole to allow for the direct measurement of the piezometric elevation at a distinct depth in a soil or rock formation.
Pliestocene	The epoch of geologic time between 1.8 million and 11 thousand years before present.
Quartzite	A metamorphic rock consisting mainly of quartz and formed by recrystallization of sandstone or chert.
Quaternary	The second periods of the Cenozoic era (following the Tertiary); thought to cover approximately the last 3 million years.
Right abutment	When looking downstream from the dam, this is the valley wall to the right on which the dam is placed.
Right lateral	Displacement along a fault such that, in plan view, the side opposite the observer appears displaced to the right.
Rock Quality Designation (RQD)	Amount (in percent) of intact core (pieces of sound core greater than 4 inches in length) in each coring interval; calculated as the sum of lengths of intact core divided by length of core run.
Serpentinite	A rock consisting almost wholly of serpentine-group minerals, e.g., antigorite and chrysotile, commonly derived from the alteration of peridotite.
Shear	An action resulting from applied forces that causes or tends to cause two contiguous parts of a body to slide relative to each other in a direction parallel to their plane of contact. Also used to describe the resulting displacement.
Siliceous Schist	Schist containing abundant free silica of either organic or inorganic origin.
Slickensides	A polished smoothly striated and often shiny surface produced by movement along a fault or landslide plane.
Stratographic	Of or pertaining to stratigraphy: the geologic study of the form, arrangement, distribution, chronologic succession, and classification of rocks.
Strike	The direction of a horizontal line on an inclined plane.
Strike slip	The component of the movement or slip that is parallel to the strike of the fault.
Strike-ridge	A ridge formed by erosion of a weaker bed beneath a more resistant bed following the strike of the bed.
Syncline	A large fold whose limbs are higher than its center, a fold with the youngest strata in the center.
Talc	An extremely soft, light green or gray monoclinic mineral.

Talus	A deposit of large angular fragments of physically weathered bedrock, usually at the base of a cliff or steep slope.
Tectonic	A branch of geology dealing with the architecture of the Earth's crust, the regional assembling of structural or deformational features such as folds and faults, a study of their mutual relations
Tertiary	The first period of the Cenozoic era (after the Cretaceous period of the Mesozoic era and before the Quaternary period); thought to span the time between approximately 65 and 1.8-million years ago.
Thrust fault	A fault with a dip of 45° or less over much of its extent, on which the hanging wall appears to have moved upward relative to the footwall. Horizontal compression rather than vertical displacement is the characteristic feature.
Unconformity	(a) A break or gap in the geologic record. (b) The structural relationship between two groups of rocks that are not in normal succession; also, their surface contact.
Weathering	To undergo changes, such as the discoloration softening, crumbling, or pitting of rock surfaces brought about by exposure to the atmosphere and its agents.


101
SUNSET RESERVOIR
UNIVERSITY MOUND RESE
280
LAKE MERCED
CRY PIPI
SAN ANDREAS PIPELINE
1
HARRY TRACY WTP
Millb
SAN ANDREAS RESERVOIR
PILARCITOS RESERVOIR
CRYSTAL SPRINGS PUMP STATION
CRYSTAL SPRINGS RESERVOIR
PULGAS BALANCIN RESERVO
VAI
205
5
SAN JOAQUIN PIPELINES
TESLA PORTAL CHLORINATION STATION
5
N
0
2.5
5
10
Miles

SITE VICINITY MAP

Figure 1-1


101
80
24
680
880
580
205
5
280
SUNSET RESERVOIR
UNIVERSITY MOUND RESERVOIR
LAKE MERCED
CRYSTAL SPRINGS PIPELINE
SAN ANDREAS PIPELINE
Hayward
HARRY TRACY WTP
Millbrae
92
SAN ANDREAS RESERVOIR
San Mateo
PILARCITOS RESERVOIR
CRYSTAL SPRINGS PUMP STATION
CRYSTAL SPRINGS RESERVOIR
CRYSTAL SPRINGS BYPASS
84
PULGAS TUNNEL
PULGAS BALANCING RESERVOIR
PULGAS VALVE LOT
Redwood City
Palo Alto
101
STANFORD TUNNEL
BAY DIVISION PIPELINES 3 & 4
Newark
BAY DIVISION PIPELINES 1 & 2
IRVINGTON TUNNEL
ALAMEDA EAST PORTAL
SAN ANTONIO RESERVOIR
COAST RANGE TUNNEL
SAN ANTONIO PUMP STATION
SUNOL VALLEY WTP
CALAVERAS RESERVOIR
Milpitas
San Jose
Sunnyvale
280
SAN JOAQUIN PIPELINES
TESLA PORTAL CHLORINATION STATION
5
N
0
2.5
5
10
Miles

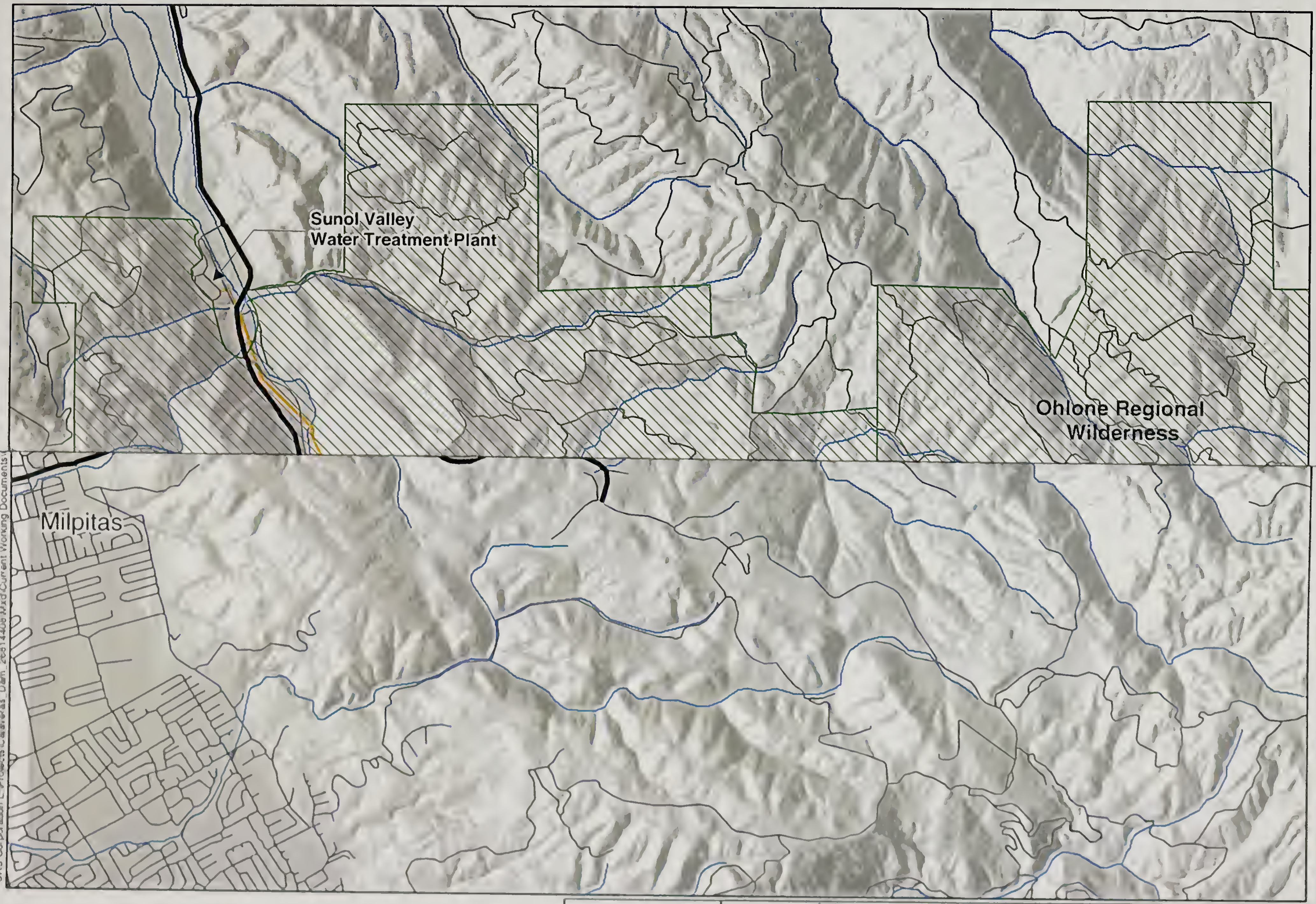
URS

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

SITE VICINITY MAP

Figure
1-1


Sunol Valley
Water Treatment Plant
Ohlone Regional
Wilderness
Milpitas
N
1
0 5
0
1
Miles

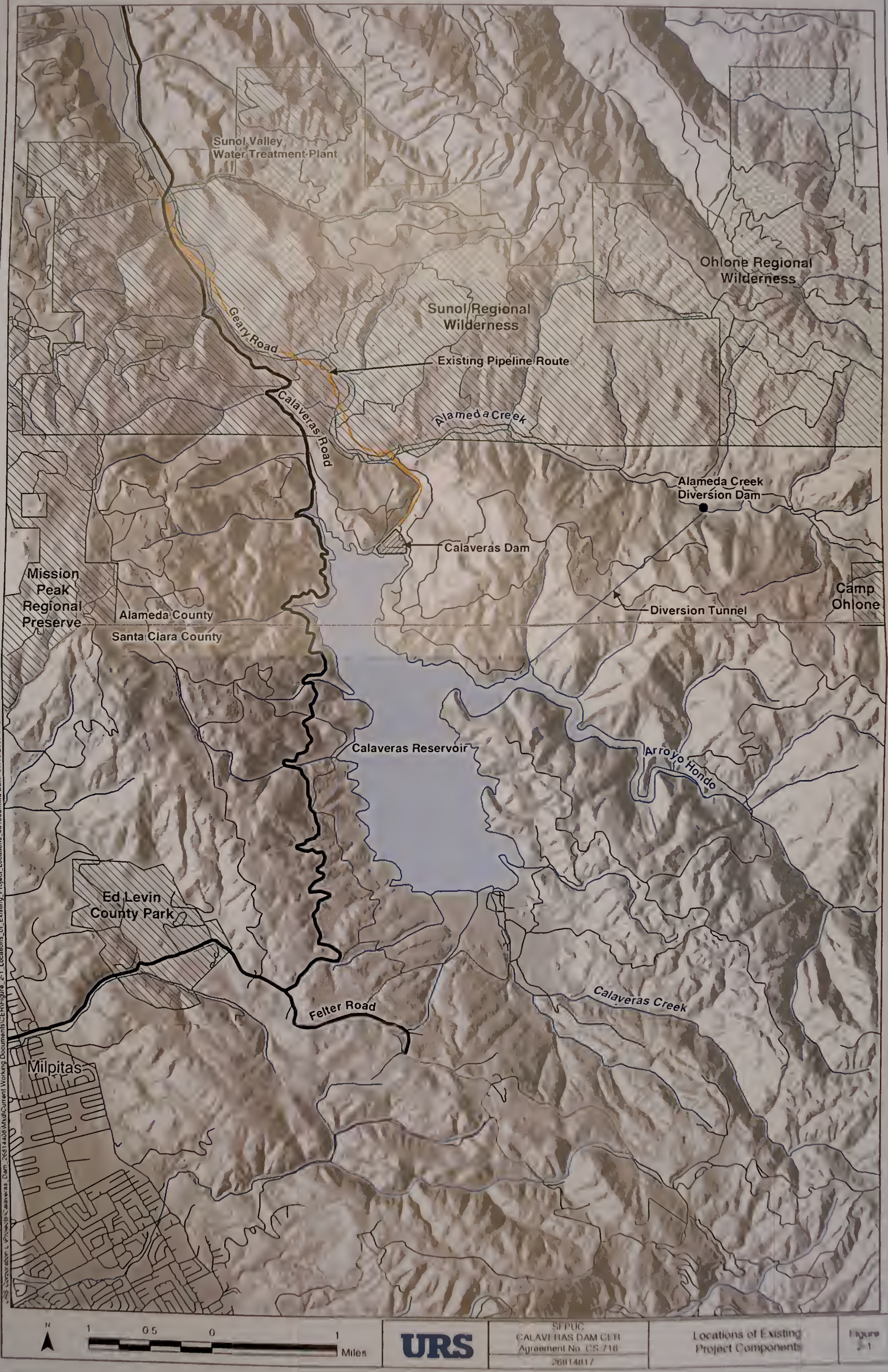
URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Locations of Existing
Project Components

Figure
2-1

URS Corporation L:\Projects\Calaveras_Dam_26814408\Mxd\Current Working Documents\


Sunol Valley Water Treatment Plant
Ohlone Regional Wilderness
Sunol Regional Wilderness
Geary Road
Existing Pipeline Route
Calaveras Road
Alameda Creek
Alameda Creek Diversion Dam
Calaveras Dam
Mission Peak Regional Preserve
Alameda County
Santa Clara County
Diversion Tunnel
Camp Ohlone
Calaveras Reservoir
Arroyo Hondo
Ed Levin County Park
Felter Road
Calaveras Creek
Milpitas
N
1
0.5
0
1
Miles

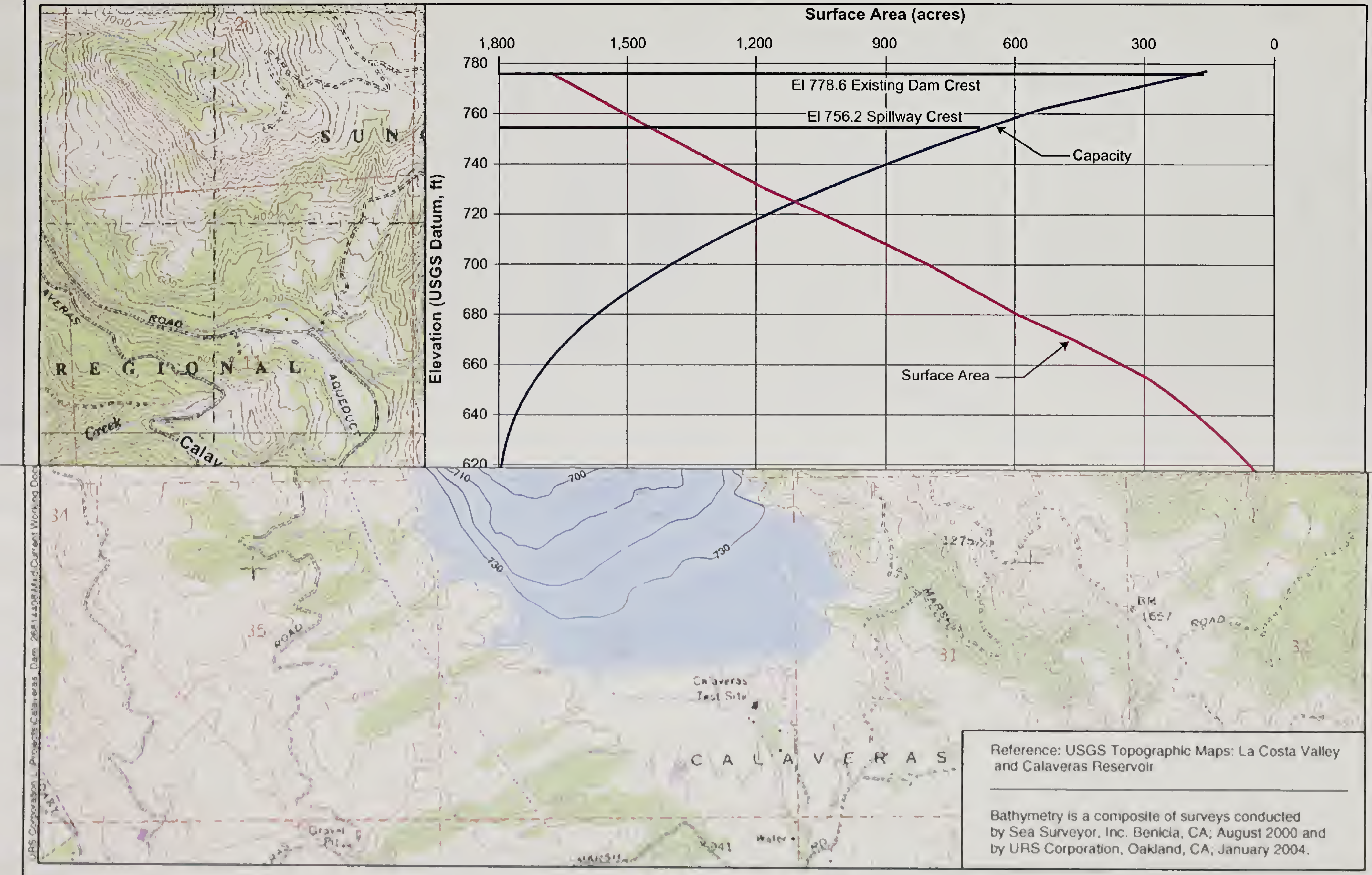
[illegible]Calaveras_Dam_26814408\Mxd\Current Working Documents\CER\Figure_2-1_Locations_of_Existing_Project_Locations_031805.mxd Date 03/18/2005 5:32:30 PM Name: akkaaleo

URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814017

Locations of Existing Project Components

Figure 2-1


Surface Area (acres)
1,800
1,500
1,200
900
600
300
0
780
760
740
720
700
680
660
640
620
Elevation (USGS Datum, ft)
El 778.6 Existing Dam Crest
El 756.2 Spillway Crest
Capacity
Surface Area
S U N
R E G I O N A L
ROAD
AQUEDUCT
Creek
Calav
710
700
730
730
1275
MARSH
BM
1657
ROAD
31
34
35
ROAD
Calaveras
Test Site
C A L A V E R A S
Gravel
Pit
Water
2041
MARSH
URS Corporation L:\Projects\Calaveras Dam 26814408\Mxd\Current Working Doc

Reference: USGS Topographic Maps: La Costa Valley and Calaveras Reservoir

Bathymetry is a composite of surveys conducted by Sea Surveyor, Inc. Benicia, CA; August 2000 and by URS Corporation, Oakland, CA; January 2004.

RESERVOIR PLAN

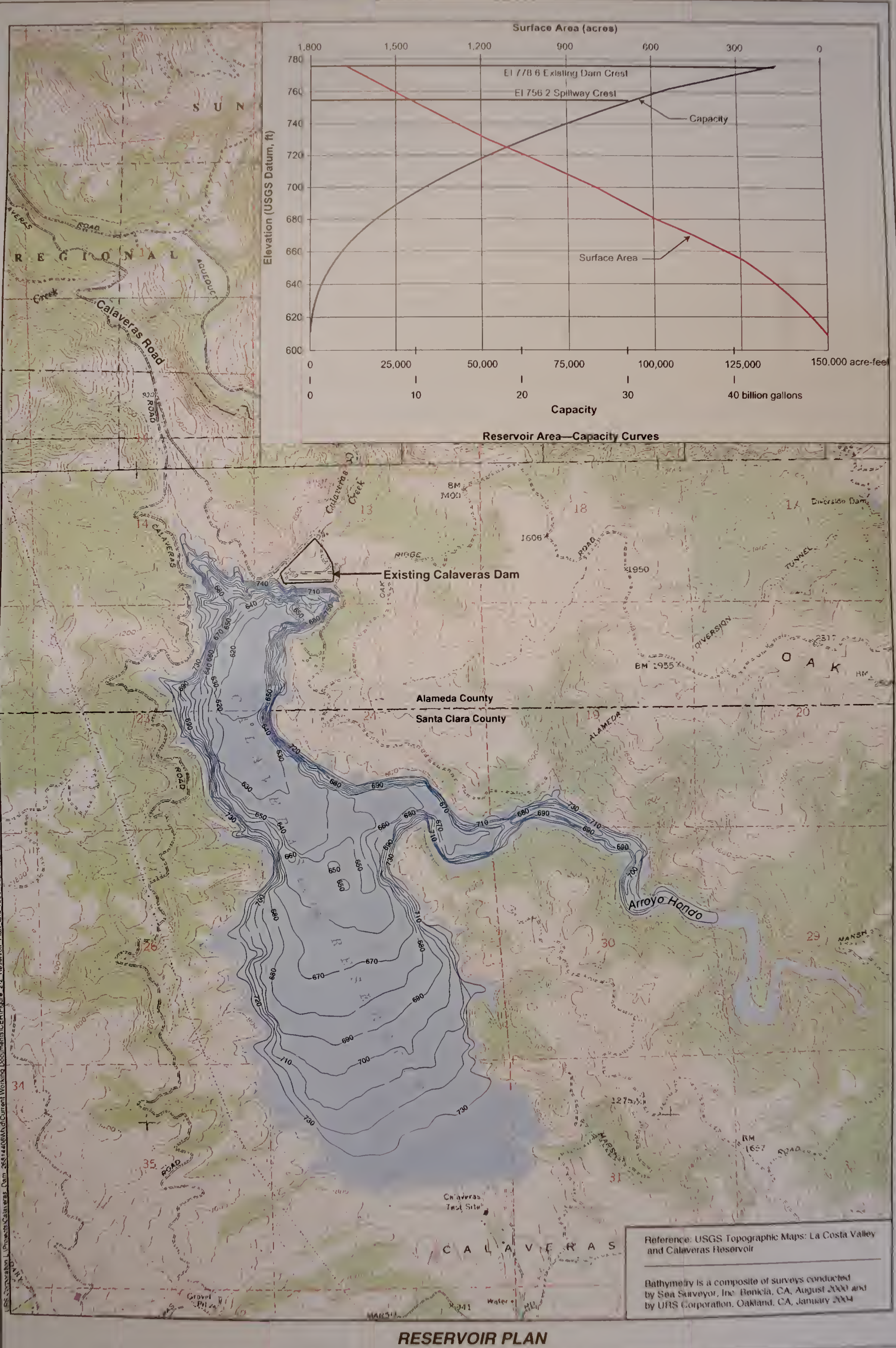
N
0
1,000
2,000
4,000
Feet

URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Reservoir Plan and
Area-Capacity Curves

Figure
2-2


Surface Area (acres)
1,800
1,500
1,200
900
600
300
0
Elevation (USGS Datum, ft)
780
760
740
720
700
680
660
640
620
600
El 778.6 Existing Dam Crest
El 756.2 Spillway Crest
Capacity
Surface Area
0
25,000
50,000
75,000
100,000
125,000
150,000 acre-feet
0
10
20
30
40 billion gallons
Capacity
Reservoir Area—Capacity Curves
S U N
R E G I O N A L
Calaveras Road
Creek
AQUEDUCT
ROAD
CALAVERAS
Calaveras Creek
13
14
18
BM M00
1606
RIDGE
ROAD
1950
TUNNEL
Diversion Dam
Existing Calaveras Dam
DIVERSION
BM 1935
O A K
Alameda County
Santa Clara County
19
20
ALAMEDA
Arroyo Hondo
29
30
31
35
26
C A L A V E R A S
Calaveras Test Site
Water
Gravel Pit
MARSH
ROAD
740
710
680
650
640
620
630
660
670
690
700
720
730

Reference: USGS Topographic Maps: La Costa Valley and Calaveras Reservoir

Bathymetry is a composite of surveys conducted by Sea Surveyor, Inc. Benicia, CA, August 2000 and by URS Corporation, Oakland, CA, January 2004

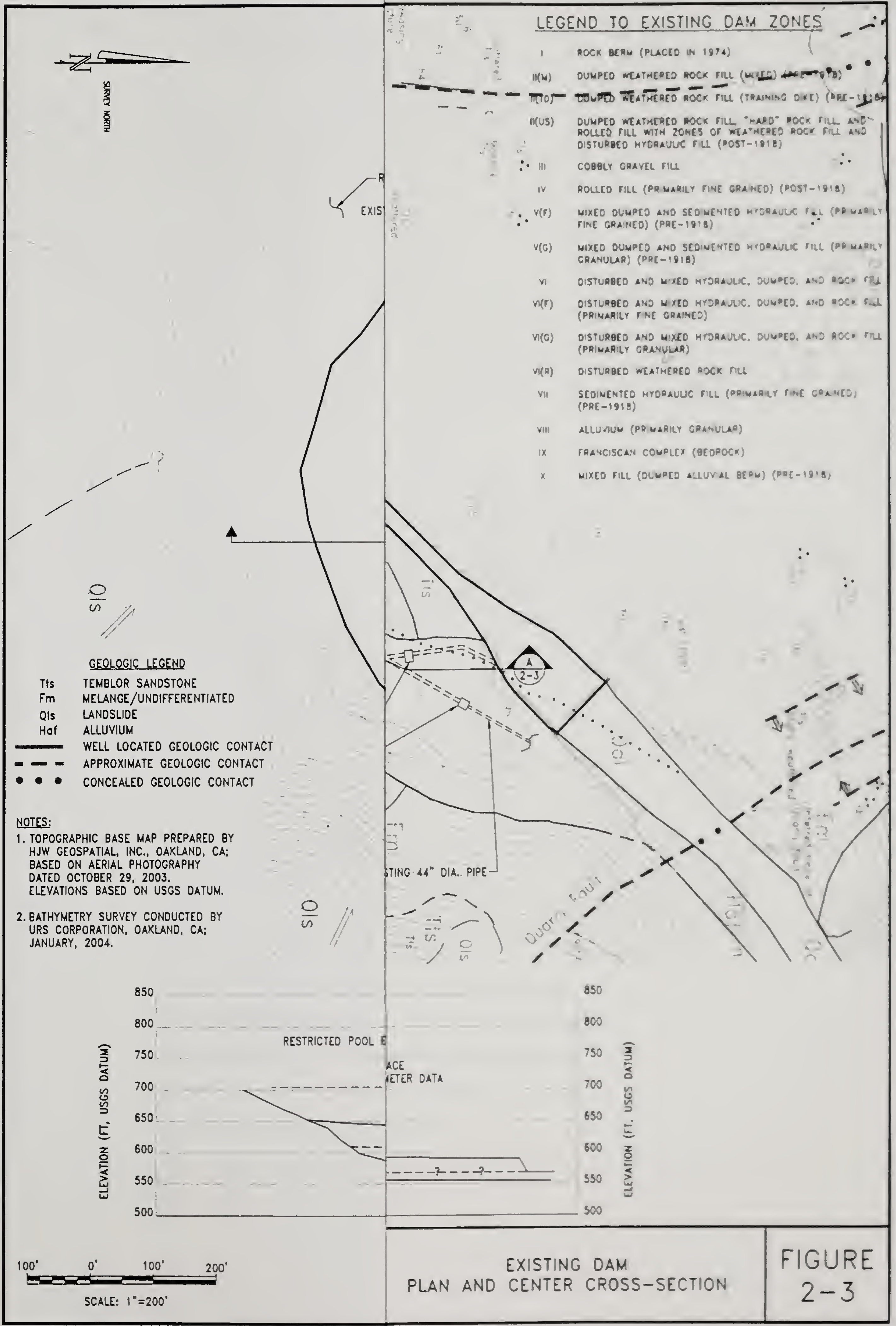
RESERVOIR PLAN

N

0 1,000 2,000 4,000 Feet

URS	SFPUC CALAVERAS DAM CER Agreement No. CS-716 26814817	Reservoir Plan and Area-Capacity Curves	Figure 2-2

\Projects\Calaveras Dam 26814408\...\Current Working Documents\CER\Figure 2-2 Reservoir Plan and Area Capacity Curves.mxd Date: 04/05/2005 3:37:23 PM Name: ekkeele0



LEGEND TO EXISTING DAM ZONES

I	ROCK BERM (PLACED IN 1974)
II(M)	DUMPED WEATHERED ROCK FILL (MIXED) (PRE-1918)
II(TD)	DUMPED WEATHERED ROCK FILL (TRAINING DIKE) (PRE-1918)
II(US)	DUMPED WEATHERED ROCK FILL, "HARD" ROCK FILL, AND ROLLED FILL WITH ZONES OF WEATHERED ROCK FILL AND DISTURBED HYDRAULIC FILL (POST-1918)
III	COBBLY GRAVEL FILL
IV	ROLLED FILL (PRIMARILY FINE GRAINED) (POST-1918)
V(F)	MIXED DUMPED AND SEDIMENTED HYDRAULIC FILL (PRIMARILY FINE GRAINED) (PRE-1918)
V(G)	MIXED DUMPED AND SEDIMENTED HYDRAULIC FILL (PRIMARILY GRANULAR) (PRE-1918)
VI	DISTURBED AND MIXED HYDRAULIC, DUMPED, AND ROCK FILL
VI(F)	DISTURBED AND MIXED HYDRAULIC, DUMPED, AND ROCK FILL (PRIMARILY FINE GRAINED)
VI(G)	DISTURBED AND MIXED HYDRAULIC, DUMPED, AND ROCK FILL (PRIMARILY GRANULAR)
VI(R)	DISTURBED WEATHERED ROCK FILL
VII	SEDIMENTED HYDRAULIC FILL (PRIMARILY FINE GRAINED) (PRE-1918)
VIII	ALLUVIUM (PRIMARILY GRANULAR)
IX	FRANCISCAN COMPLEX (BEDROCK)
X	MIXED FILL (DUMPED ALLUVIAL BERM) (PRE-1918)

GEOLOGIC LEGEND

Tts	TEMBLOR SANDSTONE
Fm	MELANGE/UNDIFFERENTIATED
Qls	LANDSLIDE
Haf	ALLUVIUM
▬▬	WELL LOCATED GEOLOGIC CONTACT
▬ ▬ ▬	APPROXIMATE GEOLOGIC CONTACT
● ● ●	CONCEALED GEOLOGIC CONTACT

NOTES:

1. TOPOGRAPHIC BASE MAP PREPARED BY HJW GEOSPATIAL, INC., OAKLAND, CA; BASED ON AERIAL PHOTOGRAPHY DATED OCTOBER 29, 2003. ELEVATIONS BASED ON USGS DATUM.
2. BATHYMETRY SURVEY CONDUCTED BY URS CORPORATION, OAKLAND, CA; JANUARY, 2004.

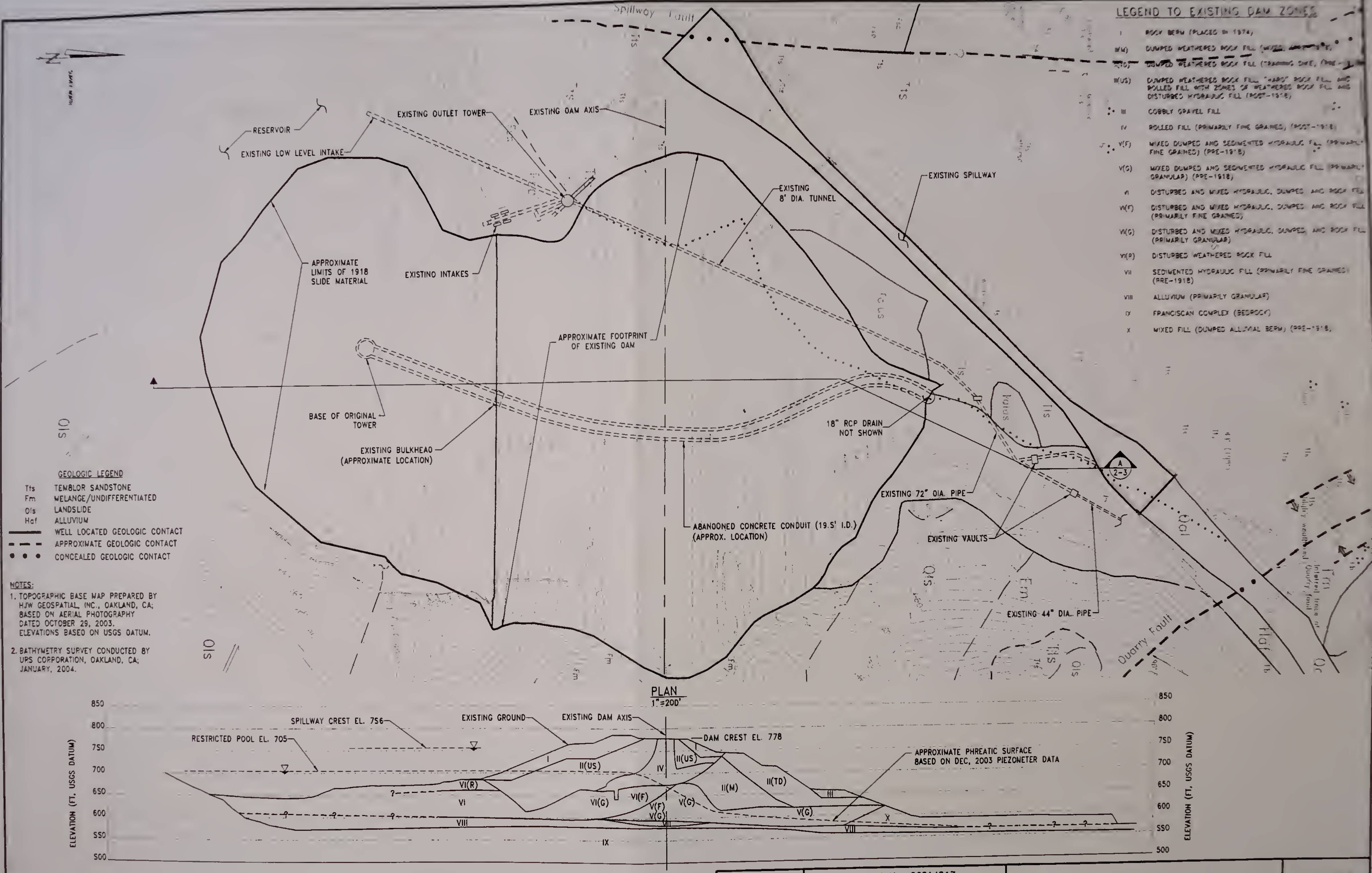
100' 0' 100' 200'

SCALE: 1"=200'

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\2-3.dwg, 2-3

EXISTING DAM
PLAN AND CENTER CROSS-SECTION

FIGURE
2-3


Spillway Fault
Tts
RESERVOIR
EXISTING LOW LEVEL INTAKE
EXISTING OUTLET TOWER
EXISTING DAM AXIS
EXISTING SPILLWAY
EXISTING 8' DIA. TUNNEL
APPROXIMATE LIMITS OF 1918 SLIDE MATERIAL
EXISTING INTAKES
APPROXIMATE FOOTPRINT OF EXISTING DAM
BASE OF ORIGINAL TOWER
EXISTING BULKHEAD (APPROXIMATE LOCATION)
18" RCP DRAIN NOT SHOWN
ABANDONED CONCRETE CONDUIT (19.5' I.D.) (APPROX. LOCATION)
EXISTING 72" DIA. PIPE
EXISTING VAULTS
EXISTING 44" DIA. PIPE
A 2-3
Qal
Qls
Fm
Hof
Quarry Fault
Inferred trace of Quarry fault
PLAN
1"=200'
850
800
750
700
650
600
550
500
ELEVATION (FT, USGS DATUM)
SPILLWAY CREST EL. 756
RESTRICTED POOL EL. 705
EXISTING GROUND
EXISTING DAM AXIS
DAM CREST EL. 778
APPROXIMATE PHREATIC SURFACE BASED ON DEC, 2003 PIEZOMETER DATA
I
II(US)
IV
II(M)
II(TD)
III
VI(R)
VI
VI(G)
VI(F)
V(F)
V(G)
VII
VIII
IX
X
?
100'
0'
100'
200'
SCALE: 1"=200'

LEGEND TO EXISTING DAM ZONES

I	ROCK BERM (PLACED IN 1974)
II(M)	DUMPED WEATHERED ROCK FILL ([illegible])
II(TD)	DUMPED WEATHERED ROCK FILL (TRAINING DIKE, PRE-[illegible]
II(US)	DUMPED WEATHERED ROCK FILL, "HARD" ROCK FILL AND ROLLED FILL WITH ZONES OF WEATHERED ROCK FILL AND DISTURBED HYDRAULIC FILL (POST-1918)
III	COBBLY GRAVEL FILL
IV	ROLLED FILL (PRIMARILY FINE GRAINED) (POST-1918)
V(F)	MIXED DUMPED AND SEDIMENTED HYDRAULIC FILL (PRIMARILY FINE GRAINED) (PRE-1918)
V(G)	MIXED DUMPED AND SEDIMENTED HYDRAULIC FILL (PRIMARILY GRANULAR) (PRE-1918)
VI	DISTURBED AND MIXED HYDRAULIC, DUMPED AND ROCK FILL
VI(F)	DISTURBED AND MIXED HYDRAULIC, DUMPED AND ROCK FILL (PRIMARILY FINE GRAINED)
VI(G)	DISTURBED AND MIXED HYDRAULIC, DUMPED AND ROCK FILL (PRIMARILY GRANULAR)
VI(R)	DISTURBED WEATHERED ROCK FILL
VII	SEDIMENTED HYDRAULIC FILL (PRIMARILY FINE GRAINED) (PRE-1918)
VIII	ALLUVIUM (PRIMARILY GRANULAR)
IX	FRANCISCAN COMPLEX (BEDROCK)
X	MIXED FILL (DUMPED ALLUVIAL BERM) (PRE-1918)

GEOLOGIC LEGEND

Tts	TEMBLOR SANDSTONE
Fm	MELANGE/UNDIFFERENTIATED
Ols	LANDSLIDE
Haf	ALLUVIUM
▬▬	WELL LOCATED GEOLOGIC CONTACT
‒ ‒ ‒	APPROXIMATE GEOLOGIC CONTACT
● ● ●	CONCEALED GEOLOGIC CONTACT

NOTES:

1. TOPOGRAPHIC BASE MAP PREPARED BY HJW GEOSPATIAL, INC., OAKLAND, CA; BASED ON AERIAL PHOTOGRAPHY DATED OCTOBER 29, 2003. ELEVATIONS BASED ON USGS DATUM.
2. BATHYMETRY SURVEY CONDUCTED BY URS CORPORATION, OAKLAND, CA; JANUARY, 2004.

CENTER CROSS-SECTION

1"=200' (REFERENCE FOR ZONE GEOMETRY AND DESCRIPTIONS: "REPORT ON THE SEISMIC STABILITY OF CALAVERAS DAM," PLATE 3, OLIVIA CHEN CONSULTANTS, 2003)
(SEE LEGEND FOR ZONE DESCRIPTIONS)

A
2-3

URS

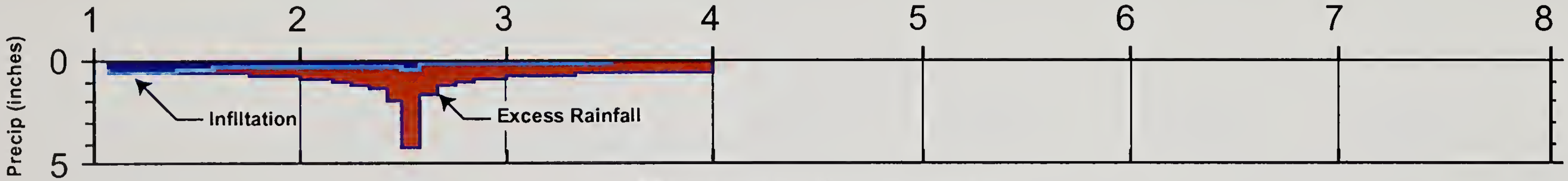
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

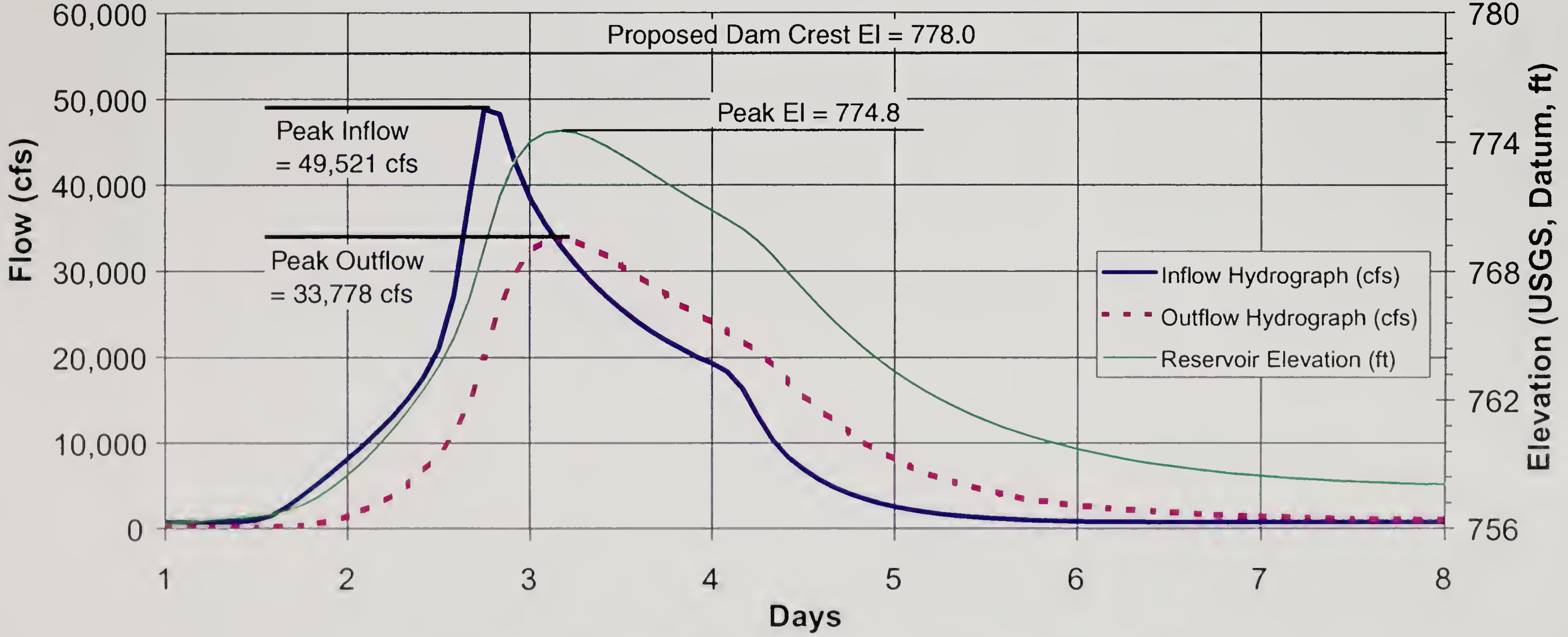
EXISTING DAM
PLAN AND CENTER CROSS-SECTION

FIGURE
2-3

J:\CAOSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\2-3.dwg, 2-3

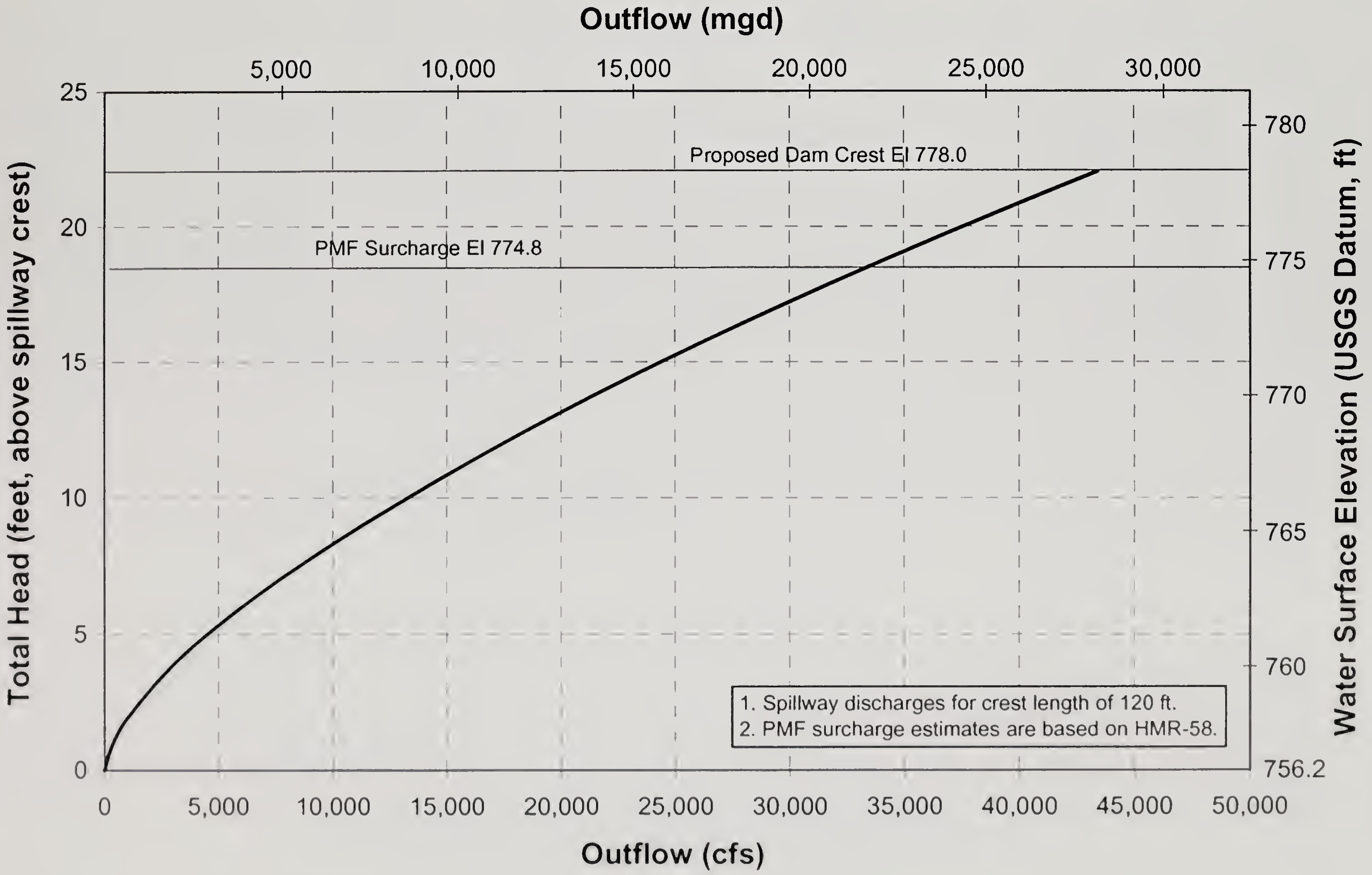


PMP Rainfal Hyetograph

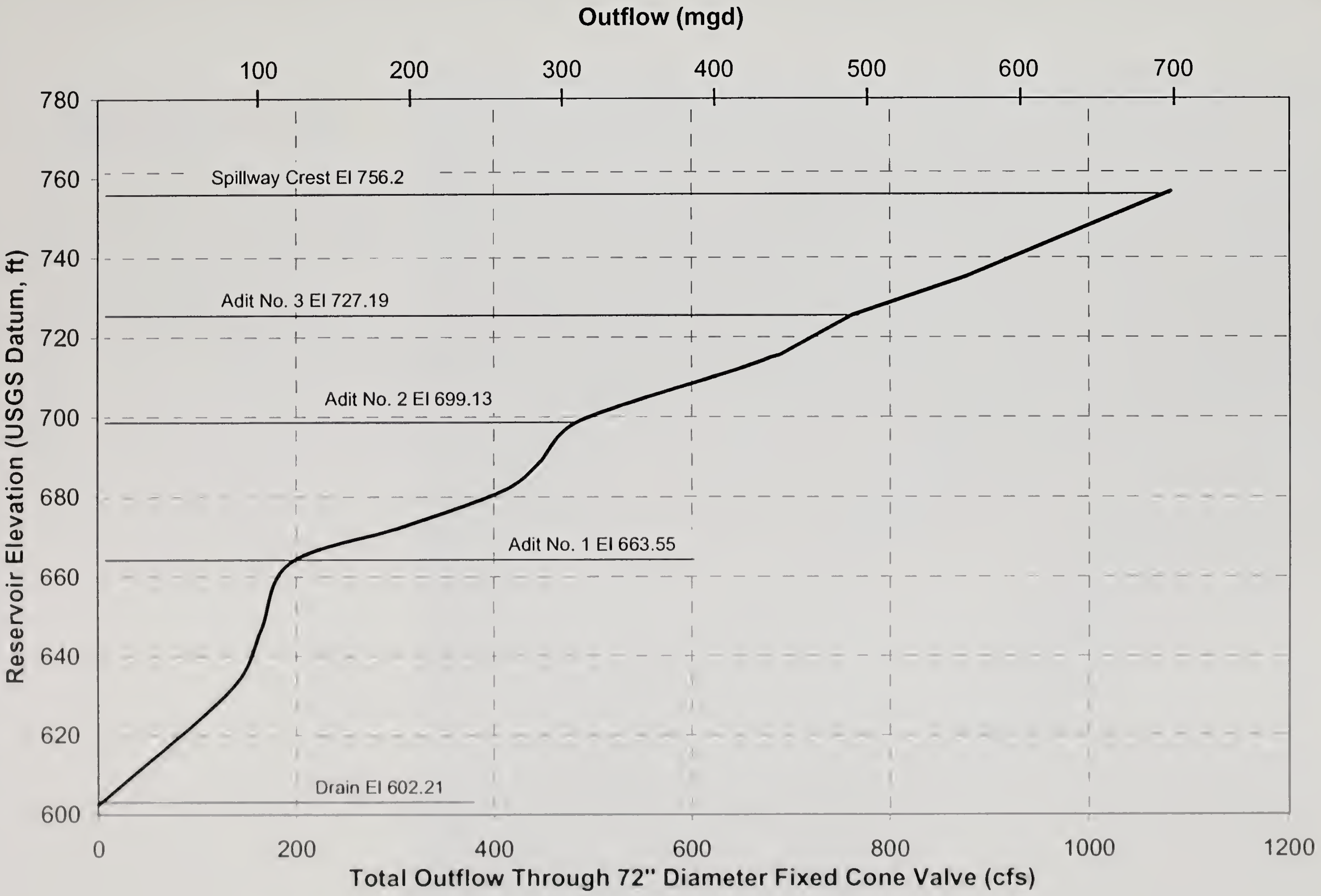


Inflow & Outflow Hydrographs & Reservoir Elevation

URS	26814817 SFPUC Calaveras Dam Agreement No. CS 716	PMP Rainfall Hyetograph, PMF Inflow and Outflow Hydrographs and Reservoir Elevation	Figure 3-1

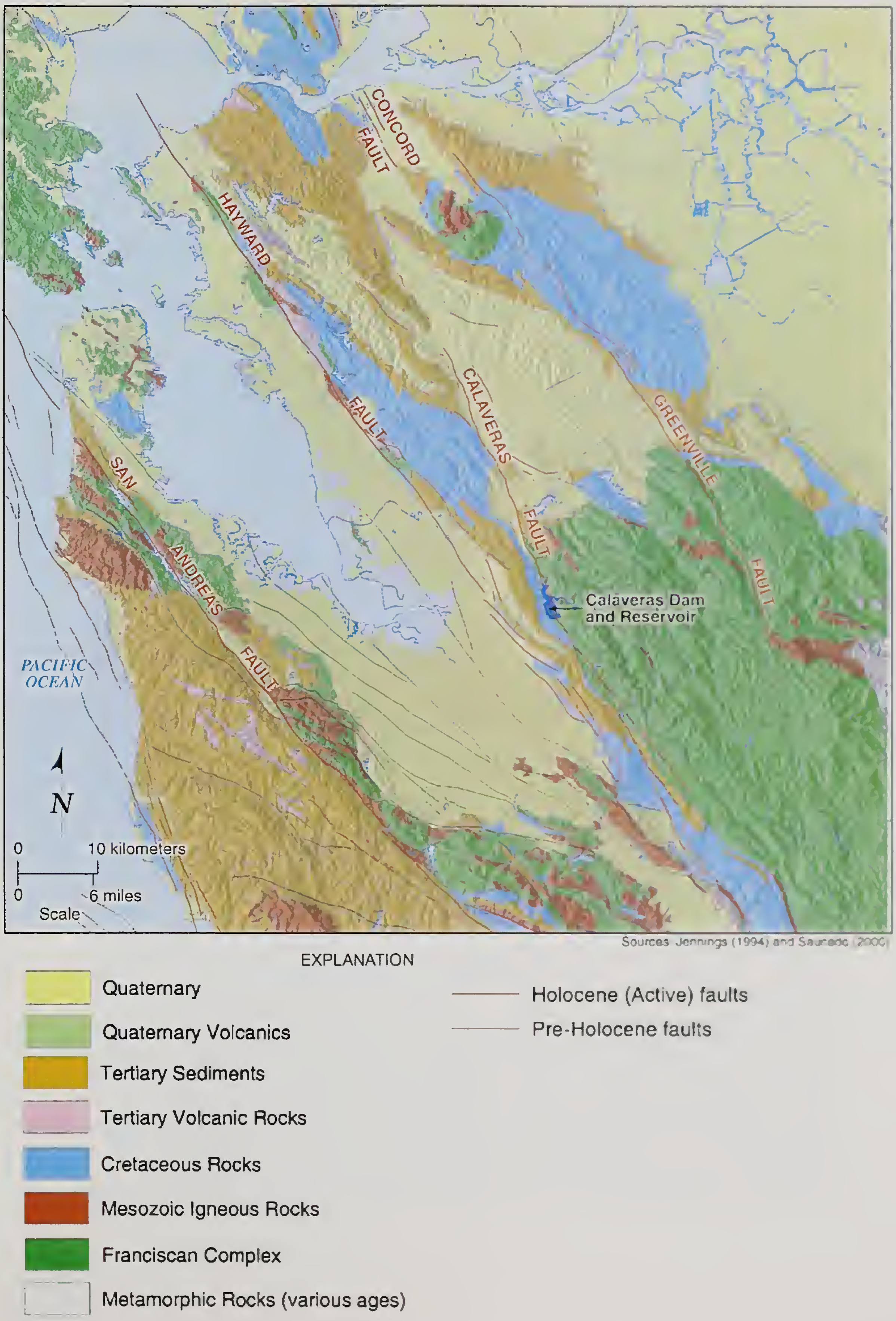


URS	26814817 SFPUC Calaveras Dam Agreement No. CS-716	Open Channel Spillway Discharge Rating Curve	Figure 3-2



Note: Drain and Adit Elevations are at the centerline of value

URS	26814817 SFPUC Calaveras Dam Agreement No. CS-716	Existing Outflow Capacity Curve	Figure 3-3


CONCORD FAULT
HAYWARD FAULT
CALAVERAS FAULT
GREENVILLE FAULT
SAN ANDREAS FAULT
Calaveras Dam and Reservoir
PACIFIC OCEAN
N
0
10 kilometers
0
6 miles
Scale
EXPLANATION
Quaternary
Quaternary Volcanics
Tertiary Sediments
Tertiary Volcanic Rocks
Cretaceous Rocks
Mesozoic Igneous Rocks
Franciscan Complex
Metamorphic Rocks (various ages)
Holocene (Active) faults
Pre-Holocene faults

Sources: Jennings (1994) and Saucedo (2000)

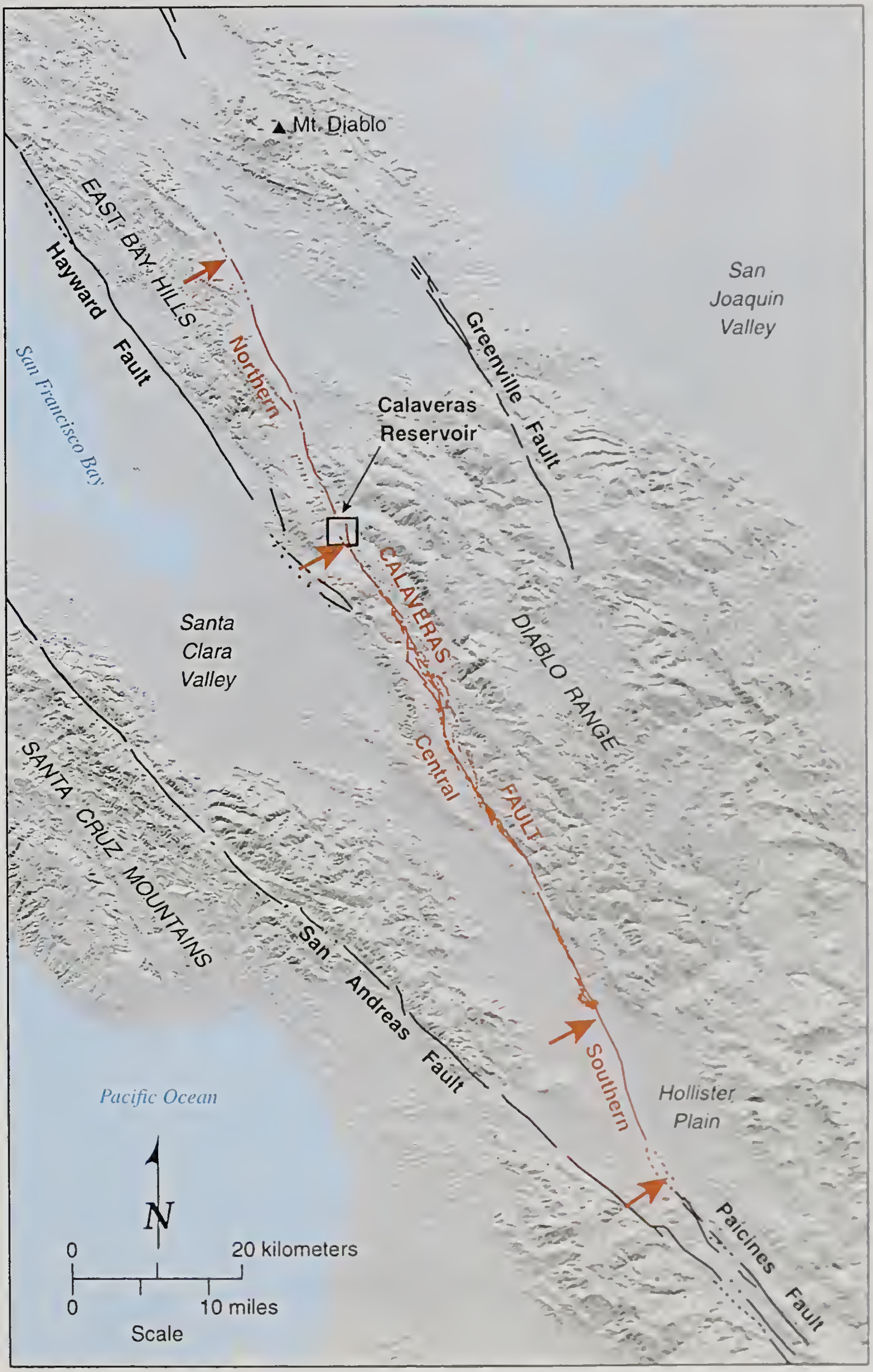
URS

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

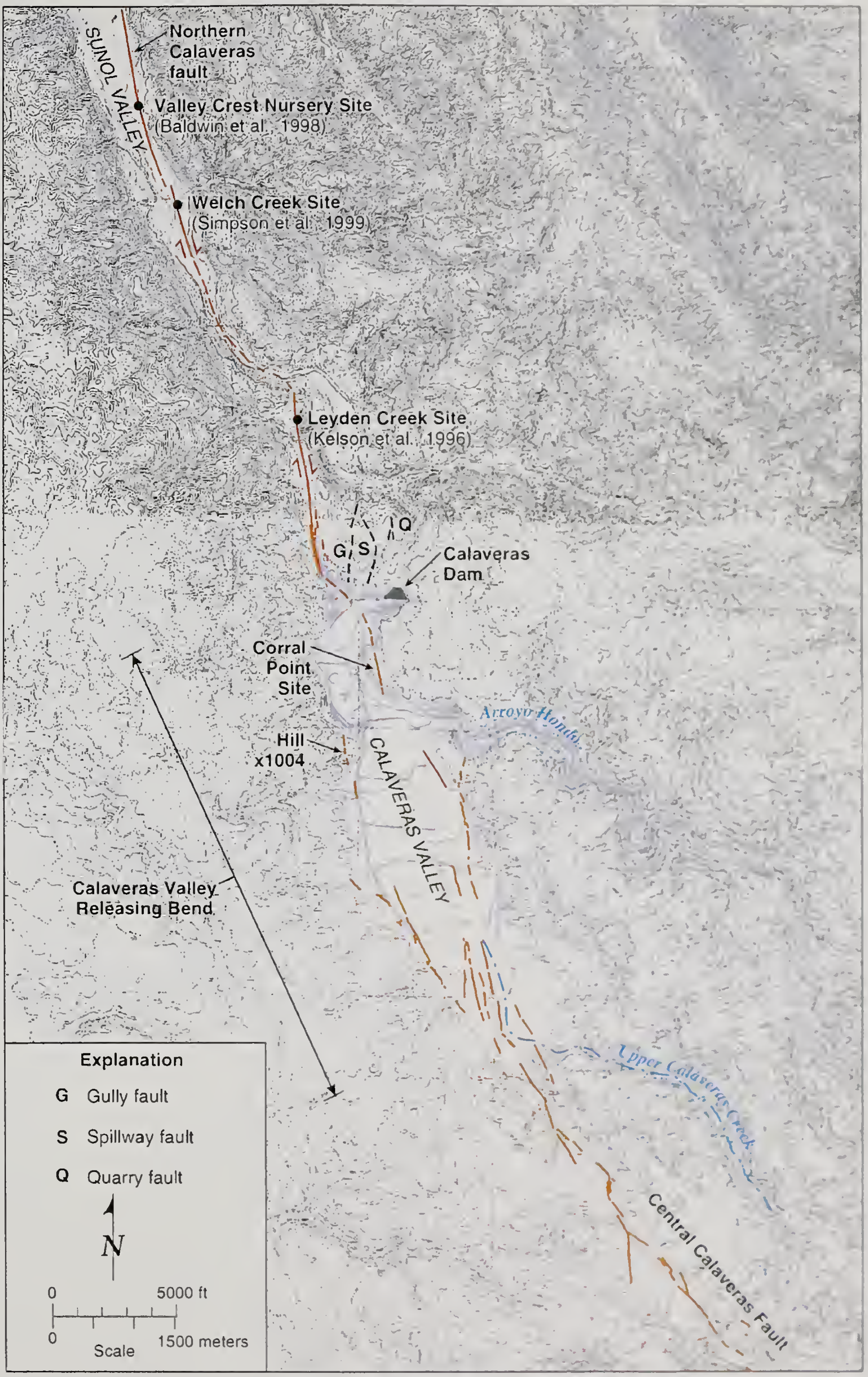
REGIONAL GEOLOGIC MAP SHOWING MAJOR FAULTS OF THE SAN ANDREAS FAULT SYSTEM IN THE SAN FRANCISCO BAY AREA

Figure
4-1


Mt. Diablo
EAST BAY HILLS
Hayward Fault
San Francisco Bay
Northern
Calaveras Reservoir
Greenville Fault
San Joaquin Valley
Santa Clara Valley
CALAVERAS FAULT
Central
DIABLO RANGE
SANTA CRUZ MOUNTAINS
San Andreas Fault
Southern
Hollister Plain
Pacific Ocean
Paicines Fault
N
0
20 kilometers
0
10 miles
Scale

Source: WGCEP, 2003

URS	SFPUC Calaveras Dam Agreement No. CS-716 Project No. 26814817	MAJOR ACTIVE FAULTS IN THE SOUTHERN SAN FRANCISCO BAY REGION WITH BOUNDARIES OF CALAVERAS FAULT SEGMENTS	Figure 4-2


Northern Calaveras fault
SUNOL VALLEY
Valley Crest Nursery Site (Baldwin et al., 1998)
Welch Creek Site (Simpson et al., 1999)
Leyden Creek Site (Kelson et al., 1996)
G
S
Q
Calaveras Dam
Corral Point Site
Arroyo Hondo
Hill x1004
CALAVERAS VALLEY
Calaveras Valley Releasing Bend
Upper Calaveras Creek
Central Calaveras Fault
Explanation
G Gully fault
S Spillway fault
Q Quarry fault
N
0
5000 ft
0
Scale
1500 meters

Base Map: La Costa Valley and Calaveras Reservoir 7.5-minute quadrangles
1899 San Jose 15-minute quadrangle beneath Calaveras Reservoir

Fault interpretations by: Witter et al. (2003), WLA (2004)

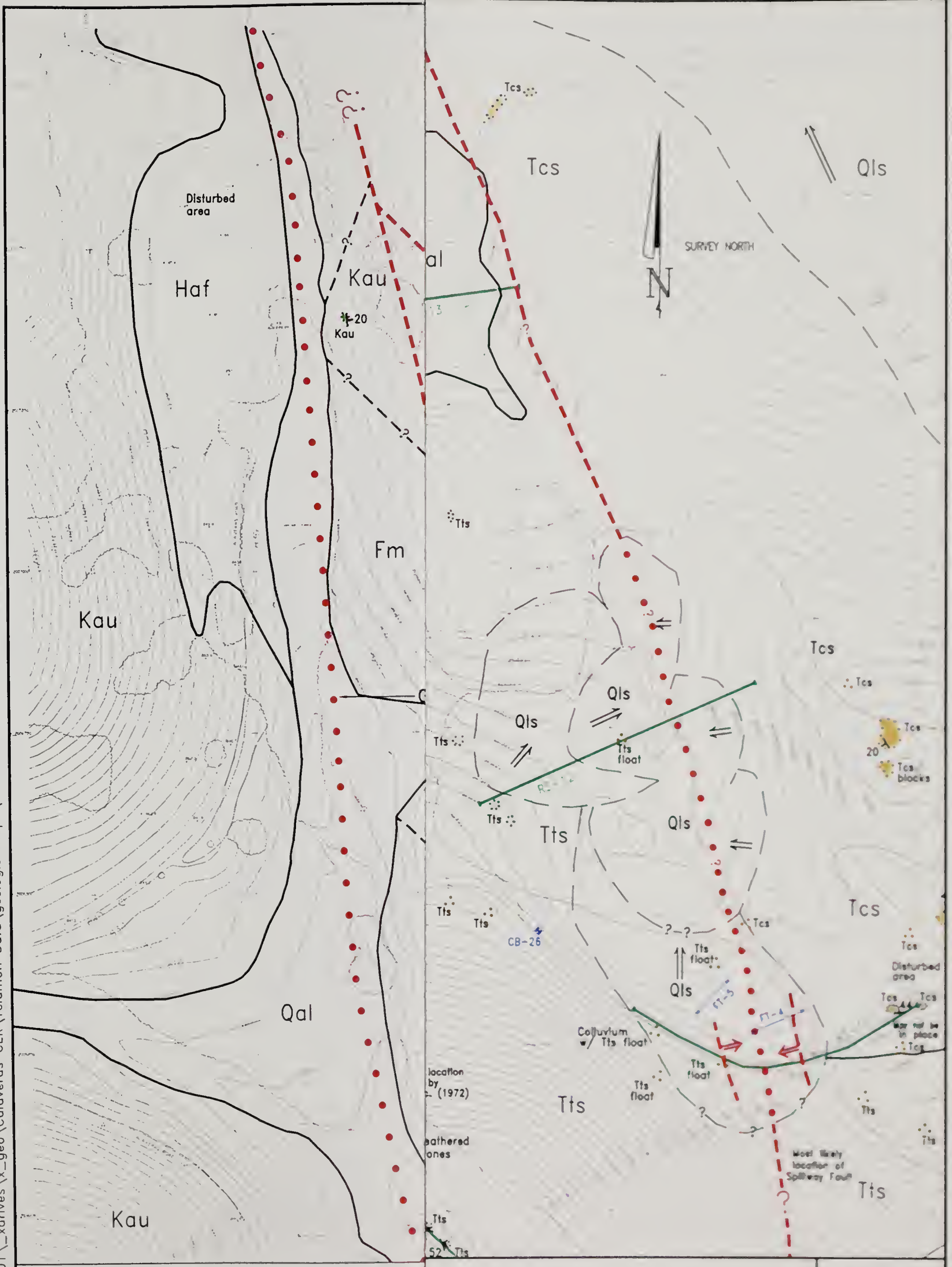
URS

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

GENERALIZED FAULT MAP OF THE
CALAVERAS VALLEY AREA

Figure
4-3


Disturbed area
Haf
Kau
Kau
Kau
20
Fm
al
Qal
Tcs
Tcs
Tcs
Tcs
Tcs
20
Tcs blocks
Tcs
Disturbed area
Tcs
Tcs
may not be in place
Tcs
SURVEY NORTH
N
Qls
Qls
Qls
Qls
Qls
Tts
Tts
Tts
Tts float
Tts
Tts
Tts
Tts float
Colluvium w/ Tts float
Tts float
Tts float
Tts
Tts
Tts
Tts
Tts
Tts
52
CB-26
FT-5
FT-4
location by (1972)
athered ones
Most likely location of Spillway Fault
?

\\s074nas01_xdrives\x_geo\Calaveras CER\Telamon Data\geologic maps\Final GEO EXP LOC PLANS 4-4A THUR 4-4D.dwg, 4-4A

NOTE:

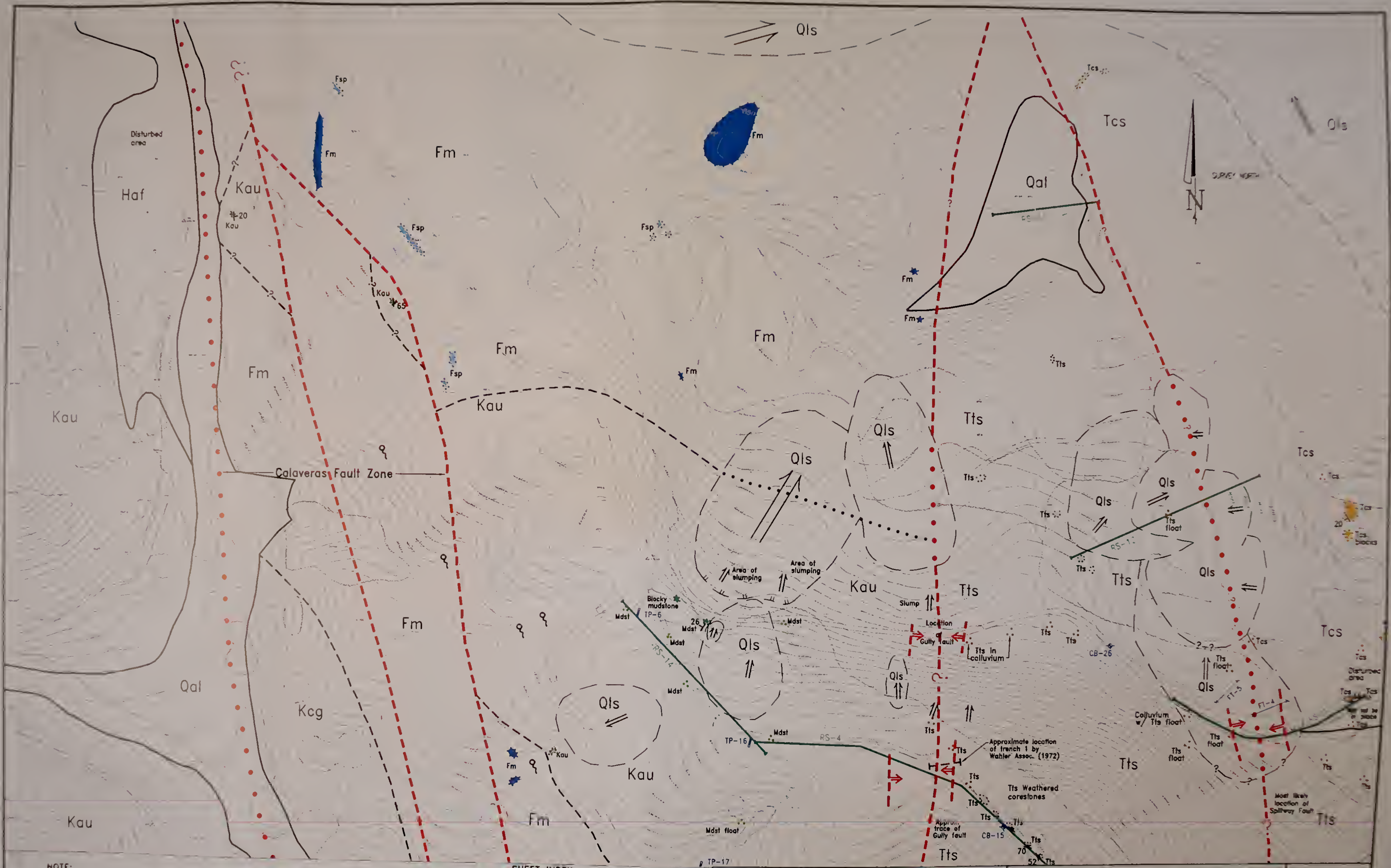
LEGEND ON FIGURE 4-4B

100'

OLOGIC AND EXPLORATION LOCATION PLAN

CALAVERAS DAM SITE

FIGURE 4-4A



Qls
Tcs
Qls
Qal
SURVEY NORTH
N
Fsp
Fm
Fm
Fm
Disturbed area
Haf
Kau
20
Kau
Fsp
Kau
65
Fm
Fm
Fm
Fsp
Fm
Fm
Kau
Kau
Tts
Qls
Qls
Tts
Tcs
Calaveras Fault Zone
Qls
Qls
Tts
Tts float
Tts
Area of slumping
Area of slumping
Kau
Slump
Tts
Qls
Blocky mudstone
TP-6
Mdst
26
Mdst
Mdst
Location of Gully fault
Tts in colluvium
CB-26
Tcs
Qls
Qls
RS-14
RS-1
Qal
Kcg
Fm
Mdst
Qls
Tts float
Qls
FT-5
FT-4
Colluvium w/ Tts float
Disturbed area
Tcs
Tts
Qls
Kau
Fm
Kau
TP-16
Mdst
RS-4
Approximate location of trench 1 by Wahler Assoc. (1972)
Tts
Tts Weathered corestones
Tts
Tts float
Tts float
Tts
Approx. trace of Gully fault
CB-15
70
52
Most likely location of Spillway Fault
Tts
Kau
Fm
Mdst float
TP-17
Tts

NOTE:

LEGEND ON FIGURE 4-4B

100' 0' 100' 200' 400'

1" = 200'

SHEET INDEX

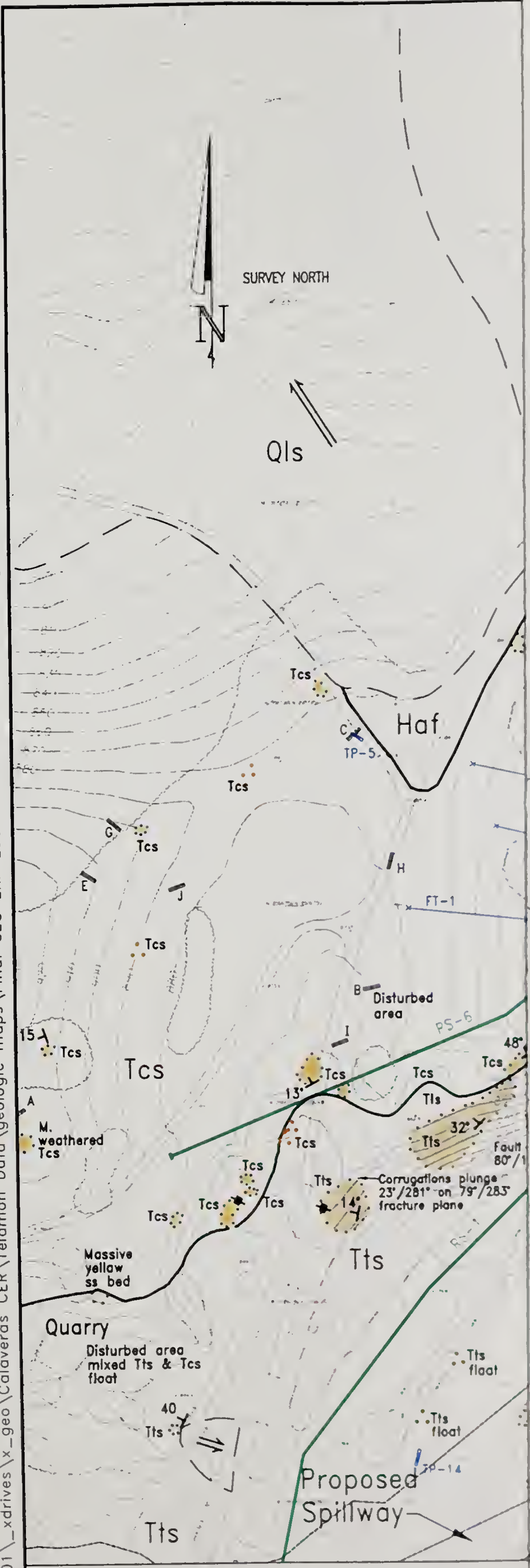
URS

Project No. 26814817

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716

GEOLOGIC AND EXPLORATION LOCATION PLAN
CALAVERAS DAM SITE

FIGURE
4-4A


SURVEY NORTH
N
Qls
Tcs
C
TP-5
Haf
Tcs
G
Tcs
E
J
H
FT-1
Tcs
B
Disturbed area
PS-6
15
Tcs
Tcs
I
48°
Tcs
Tcs
Tcs
13°
Tls
A
M. weathered Tcs
Tcs
32°
Tts
Fault 80°/1
Tcs
Tts
Corrugations plunge 23°/281° on 79°/283° fracture plane
Tcs
Tcs
14°
Tcs
Tts
Massive yellow ss bed
Quarry
Disturbed area mixed Tts & Tcs float
Tts float
40
Tts
Tts float
TP-14
Proposed Spillway
Tts

LEGEND

OBJECT	EXPLANATION
86 U D	FAULT, SOLID WHERE WELL LOCATED, DASHED WHERE APPROXIMATE, DOTTED WHERE CONCEALED, QUERIED WHERE UNCERTAIN, TICK INDICATES DIP DIRECTION AND AMOUNT, ARROWS INDICATE APPARENT SENSE OF STRIKE SLIP DISPLACEMENT, U = UP, D = DOWN
	ZONE WITHIN WHICH FAULT IS CONSTRAINED (APPROXIMATE)
?	GEOLOGIC CONTACT, SOLID WHERE WELL LOCATED, DASHED WHERE APPROXIMATE, DOTTED WHERE CONCEALED, QUERIED WHERE UNCERTAIN
? ?	SYNCLINAL AXIS, APPROXIMATE AND UNCERTAIN, ARROWS SHOW DIRECTION OF PLUNGE

		900	TOPOGRAPHIC CONTOURS (FEET)
	SHEAR	30	STRIKE AND DIP OF BEDDING (QUERY INDICATE UNCERTAIN IN BEDDING OR FRACTURE)
Tts	FLOAT OBSERVED IN FIELD	77	STRIKE AND DIP JOINT OR FRACTURE
	SPRING	80	STRIKE AND DIP OF CLEAVAGE OR FOLIATION
		⇄	LANDSLIDE (HEADSCARP INDICATED)
PS-1	SEISMIC REFRACTION LINE		
FT-1	FAULT TRENCH		
TP-1	URS TEST PIT		
A	WA TEST PIT (WAHLER, 1974)	◆	BORING, (WAHLER, 1972 & 1974)
CB-1	URS CORE BORING	◎	BORING, (DCC, 2001 & 2002)
BA-1	URS BUCKET AUGER BORING		

QUATERNARY		CRETACEOUS BERRYESSA FORMATION	
Haf	ARTIFICIAL FILL	Kcu	MUDSTONE (Mdst)
Qls	LANDSLIDE	Kcg	CONGLOMERATE
Qal	ALLUVIUM	Kss	SANDSTONE
Qt	FLUVIAL TERRACE DEPOSIT	JURASSIC-CRETACEOUS FRANCISCAN COMPLEX	
TERTIARY			
Tcs	CLAREMONT FORMATION	Fsp	SERPENTINITE
Tts	TEMBLOR SANDSTONE	Fb	GLAUCOPHANE BLUESCHIST
		Fsp	MELANGE/UNDIFFERENTIATED

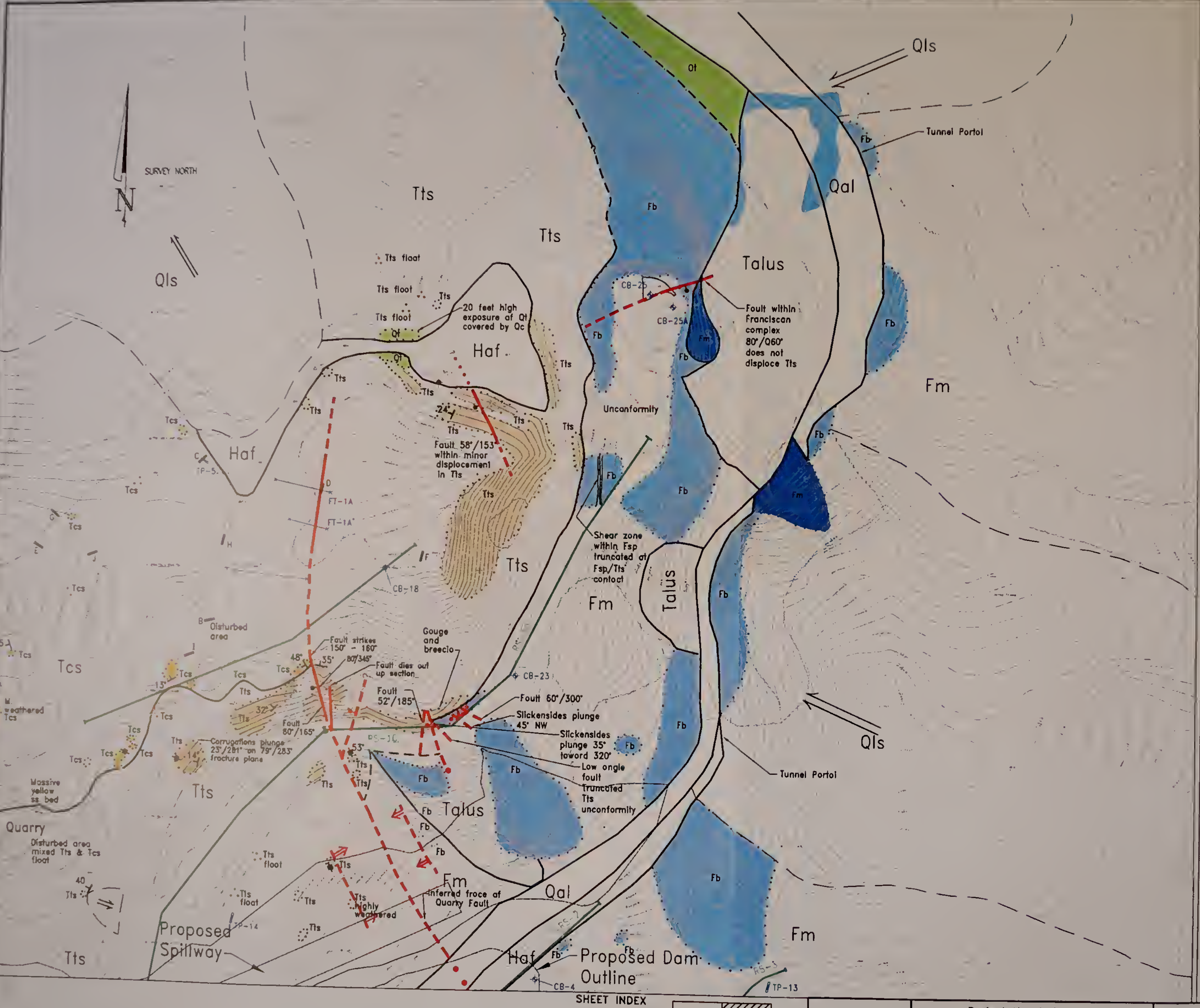
NOTES:

1. Base map was prepared using computer assisted, photogrammertic methods by HJW Geospatial, Inc., in Oakland, California.
2. Date of aerial photography 10-29-03.
3. Control survey performed by McGill Martin Self, Inc., Walnut Creek, CA.
4. The grid is based on the California Coordinate System, Zone III, Nad 1983.
5. Elevations are based on USGS datum.
6. In areas of dense vegetation, accuracy of contours may deviate from accepted accuracy standards.
7. Geology based on field mappping, air photo interpretation, and in part modified from Dibiee (1973) and Marliave (1935). Landslides are modified from Nilsen (1975).
8. Geologic mapping was conducted by URS and WLA between Oct. 28, 2003 and April 15, 2004.
9. Colored areas indicate surface exposure of mapped units.
10. Not all outcrops observed in field are shown.
11. See Geotechnical Data Report (URS, 2005) for boring logs, seismic surveys, and other data.

100

OLOGIC AND EXPLORATION LOCATION PLAN
CALAVERAS DAM SITE

FIGURE
4-4B


SURVEY NORTH
N
Qls
Tts
Tts
Tts float
Tts float
Tts float
Qt
20 feet high exposure of Qt covered by Qc
Haf
Haf
Tcs
Tts
Fault 58°/153° within minor displacement in Tts
FT-1A
FT-1A'
CB-18
Disturbed area
Tcs
Fault strikes 150° - 160°
80/345°
Fault dies out up section
Fault 52°/185°
Fault 80°/165°
Gouge and breccia
Corrugations plunge 23°/281° on 79°/283° fracture plane
Massive yellow ss bed
weathered Tcs
Quarry
Disturbed area mixed Tts & Tcs float
Tts float
Tts highly weathered
Inferred trace of Quarry Fault
Proposed Spillway
TP-14
Qt
Fb
CB-25
CB-25A
Fm
Fault within Franciscan complex 80°/Q60° does not displace Tts
Talus
Qal
Tunnel Portal
Fm
Unconformity
Shear zone within Fsp truncated at Fsp/Tts' contact
Fm
Talus
CB-23
Fault 60°/300°
Slickensides plunge 45° NW
Slickensides plunge 35° toward 320°
Low angle fault truncated Tts unconformity
Talus
Fm
Qal
Qls
Tunnel Portal
Fm
Haf
Proposed Dam Outline
CB-4
RS-3
TP-13

LEGEND

OBJECT EXPLANATION

FAULT, SOLID WHERE WELL LOCATED, DASHED WHERE APPROXIMATE, DOTTED WHERE CONCEALED, QUERIED WHERE UNCERTAIN. TICK INDICATES DIP DIRECTION AND AMOUNT. ARROWS INDICATE APPARENT SENSE OF STRIKE SLIP DISPLACEMENT, U = UP, D = DOWN

ZONE WITHIN WHICH FAULT IS CONSTRAINED (APPROXIMATE)

GEOLOGIC CONTACT, SOLID WHERE WELL LOCATED, DASHED WHERE APPROXIMATE, DOTTED WHERE CONCEALED, QUERIED WHERE UNCERTAIN

SYNCLINAL AXIS, APPROXIMATE AND UNCERTAIN, ARROWS SHOW DIRECTION OF PLUNGE

— 900 —	TOPOGRAPHIC CONTOURS (FEET)
30	STRIKE AND DIP OF BEDDING (QUERY INDICATE UNCERTAIN IN BEDDING OR FRACTURE)
77	STRIKE AND DIP JOINT OR FRACTURE
80	STRIKE AND DIP OF CLEAVAGE OR FOLIATION
	LANDSLIDE (HEADSCARP INDICATED)
	SHEAR
Tts	FLOAT OBSERVED IN FIELD
	SPRING
RS-1	SEISMIC REFRACTION LINE
FT-1	FAULT TRENCH
TP-1	URS TEST PIT
A	WA TEST PIT (WAHLER, 1974)
CB-1	URS CORE BORING
BA-1	URS BUCKET AUGER BORING
	BORING, (WAHLER, 1972 & 1974)
	BORING, (OCC, 2001 & 2002)

QUATERNARY

Haf	ARTIFICIAL FILL
Qls	LANDSLIDE
Qal	ALLUVIUM
Qt	FLUVIAL TERRACE DEPOSIT

TERTIARY

Tcs	CLAREMONT FORMATION
Tts	TEMBLOR SANDSTONE

CRETACEOUS

BERRYESSA FORMATION

🟩	MUDSTONE (Kmsr)
Kcg	CONGLOMERATE
Kss	SANDSTONE

JURASSIC-CRETACEOUS

FRANCISAN COMPLEX

Fsp	SERPENTINITE
Fb	GLAUCOPHANE BLUESCHIST
🟦	MELANGE/UNDIFFERENTIATED

NOTES:

1. Base map was prepared using computer assisted, photogrammetric methods by HJW Geospatial, Inc., in Oakland, California.
2. Date of aerial photography 10-29-03.
3. Control survey performed by McGill Martin Self, Inc., Walnut Creek, CA.
4. The grid is based on the California Coordinate System, Zone III, Nad 1983.
5. Elevations are based on USGS datum.
6. In areas of dense vegetation, accuracy of contours may deviate from accepted accuracy standards.
7. Geology based on field mapping, air photo interpretation, and in part modified from Dibblee (1973) and Marliave (1935). Landslides are modified from Nilsen (1975).
8. Geologic mapping was conducted by URS and WLA between Oct. 28, 2003 and April 15, 2004.
9. Colored areas indicate surface exposure of mapped units.
10. Not all outcrops observed in field are shown.
11. See Geotechnical Data Report (URS, 2005) for boring logs, seismic surveys, and other data.

100' 0' 100' 200' 400'

1" = 200'

SHEET INDEX

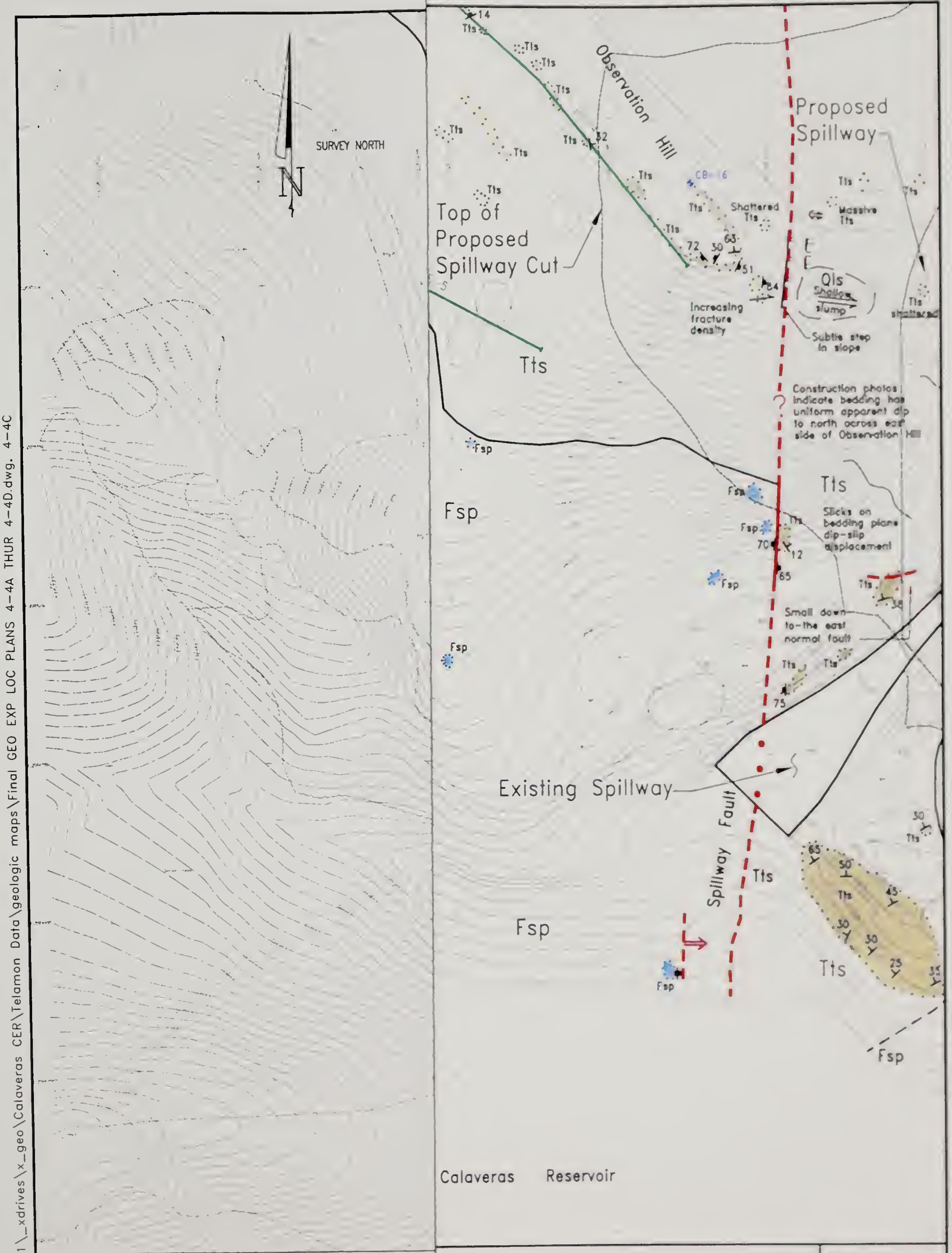
URS

Project No. 26814817

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716

GEOLOGIC AND EXPLORATION LOCATION PLAN
CALAVERAS DAM SITE

FIGURE
4-4B


14
Tts
Observation Hill
Proposed Spillway
Top of Proposed Spillway Cut
32
CB-16
Shattered Tts
Massive Tts
72
30
63
51
84
Qls
Shallow slump
Increasing fracture density
Subtle step in slope
shattered
Tts
Construction photos indicate bedding has uniform apparent dip to north across east side of Observation Hill
Fsp
Slicks on bedding plane dip-slip displacement
70
12
65
Small down-to-the east normal fault
75
Existing Spillway
Spillway Fault
65
50
45
30
30
25
35
Calaveras Reservoir
SURVEY NORTH
N
100

\\s074nas01_xdrives\x_geo\Calaveras CER\Telamon Data\geologic maps\Final GEO EXP LOC PLANS 4-4A THUR 4-4D.dwg. 4-4C

NOTE:

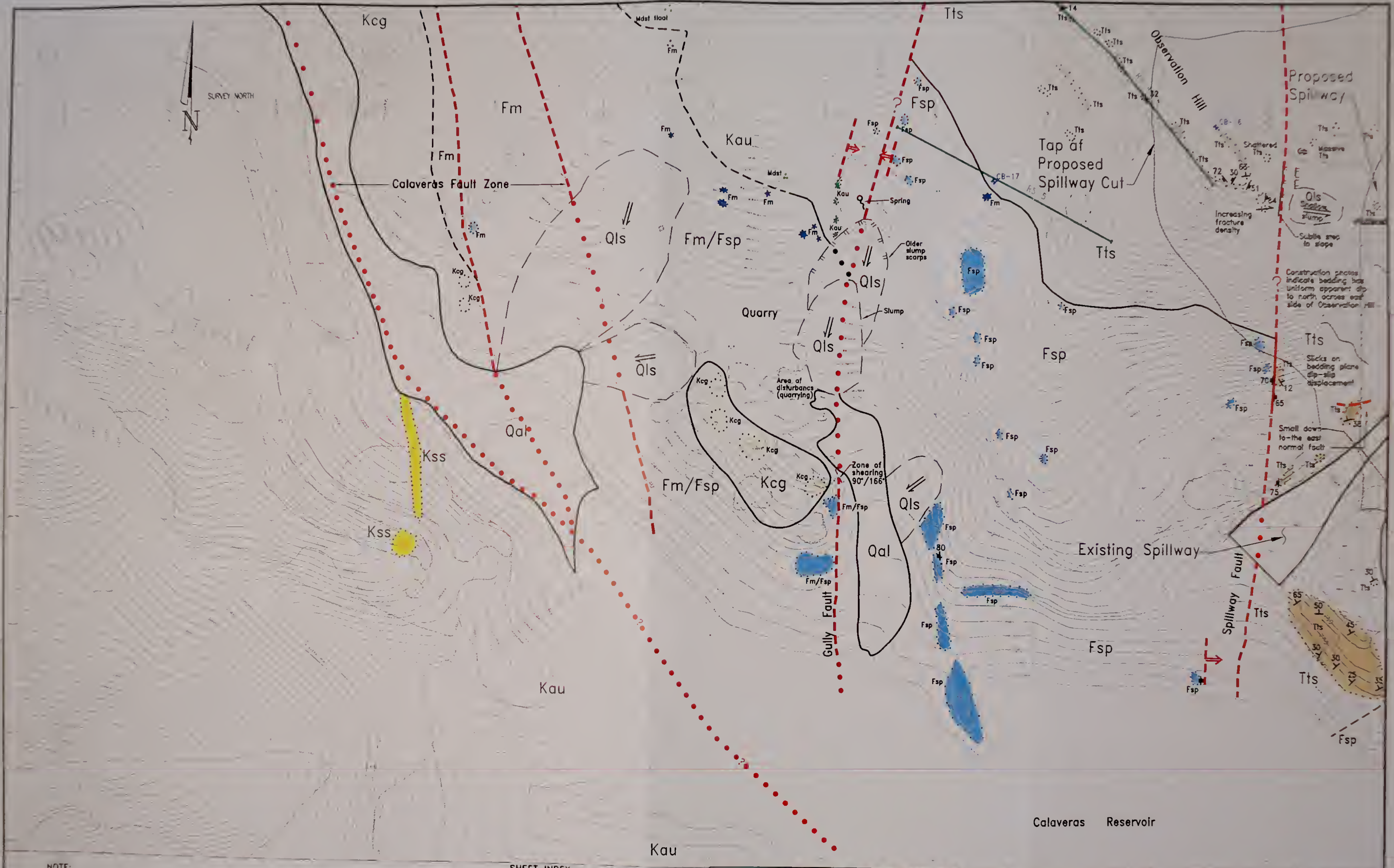
LEGEND ON FIGURE 4-4B

OLOGIC AND EXPLORATION LOCATION PLAN

CALAVERAS DAM SITE

FIGURE

4-4C


SURVEY NORTH
N
Kcg
Fm
Fm
Calaveras Fault Zone
Kcg
Kcg
Fm
Qls
Qls
Qal
Kss
Kss
Kau
Kau
Mdst float
Fm
Fm
Kau
Mdst
Fm
Fm
Fm/Fsp
Fm
Kau
Kau
Quarry
Spring
Older slump scarps
Qls
Slump
Qls
Area of disturbance (quarrying)
Kcg
Kcg
Kcg
Kcg
Kcg
Fm/Fsp
Zone of shearing 90°/166°
Fm/Fsp
Qls
Qal
Fm/Fsp
Gully Fault
Tts
Fsp
Fsp
Fsp
Fsp
Fsp
CB-17
Fm
Tts
Top of Proposed Spillway Cut
Tts
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Fsp
Observation Hill
CB-6
Shattered Tts
Massive Tts
Increasing fracture density
Qls
Shallow slump
Subtle step to slope
Proposed Spillway
Construction photos indicate bedding has uniform apparent dip to north across east side of Observation Hill
Tts
Slicks on bedding plane dip-slip displacement
Small down-to-the east normal fault
Existing Spillway
Spillway Fault
Tts
Tts
Fsp
Calaveras Reservoir
Kau
100' 0' 100' 200' 400'
1" = 200'
SHEET INDEX

NOTE:

LEGEND ON FIGURE 4-4B

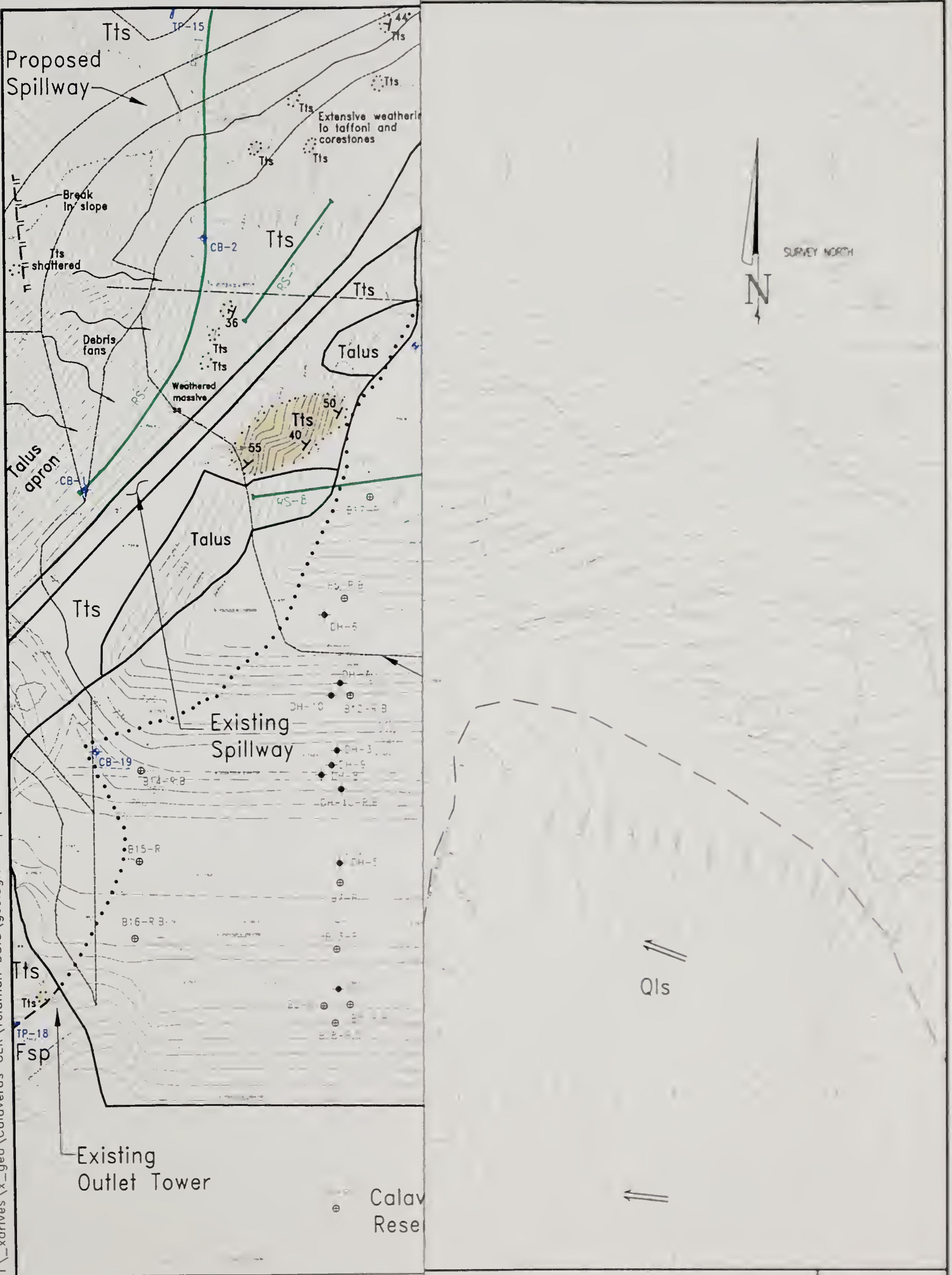
URS

Project No. 26814817

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716

GEOLOGIC AND EXPLORATION LOCATION PLAN
CALAVERAS DAM SITE

FIGURE
4-4C



Tts
TP-15
Proposed Spillway
Tts
Tts
Tts
Extensive weatheri
to taffoni and
corestones
Tts
Tts
Break in slope
Tts shattered
CB-2
Tts
RS-7
Tts
36
Tts
Tts
Debris fans
RS-
Weathered massive ss
Talus
50
Tts
40
55
Talus apron
CB-1
RS-8
Talus
Tts
DH-5
DH-10
Existing Spillway
CB-19
B15-R
Tts
Tts
TP-18
Fsp
Existing Outlet Tower
Calav
Rese
SURVEY NORTH
N
Qls
100

NOTE:

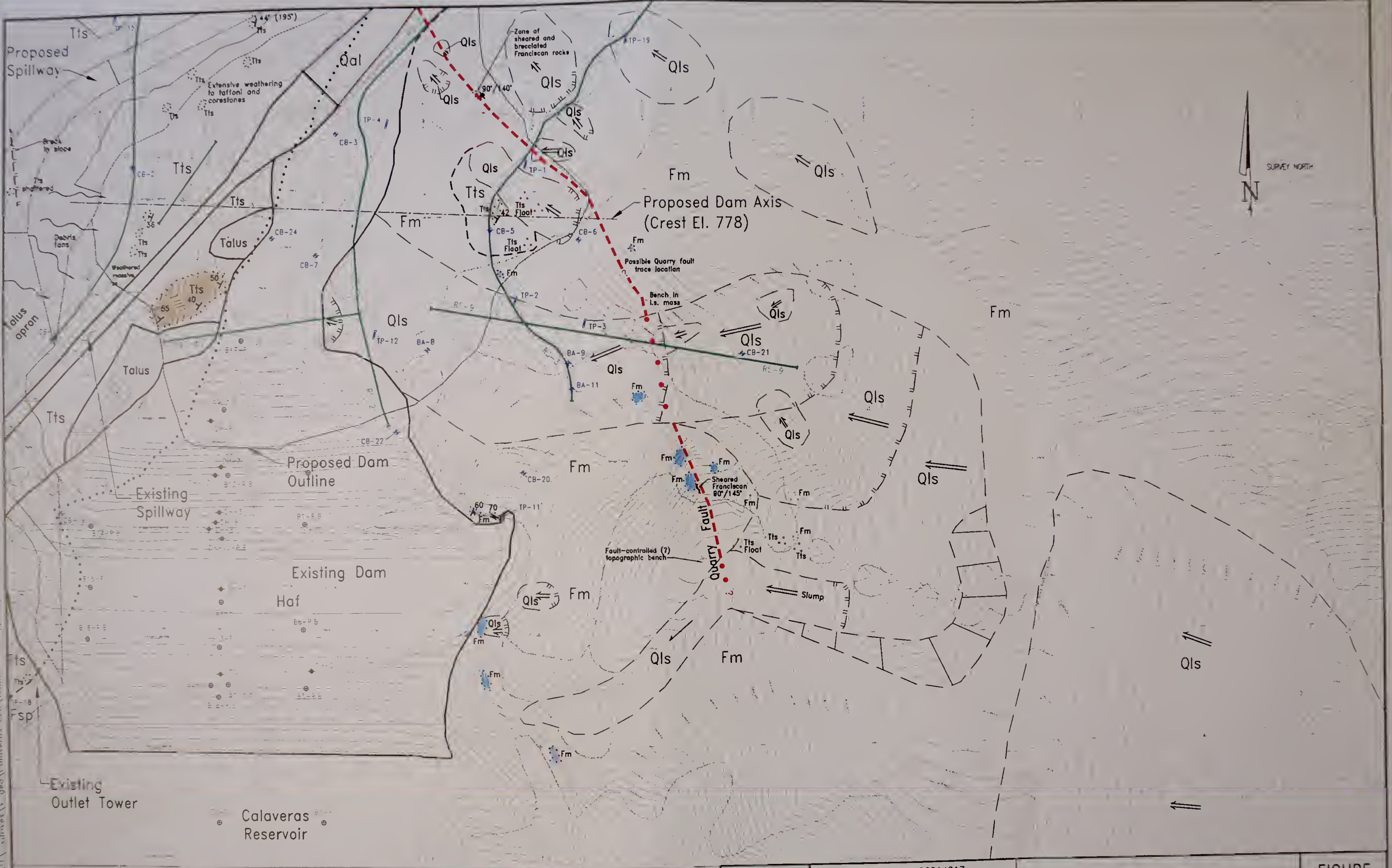
LEGEND ON FIGURE 4-4B

OLOGIC AND EXPLORATION LOCATION PLAN

CALAVERAS DAM SITE

FIGURE 4-4D

\\s074nas01_xdrives\x_geo\Calaveras CER\Telaman Data\geologic maps\Final GEO EXP LOC PLANS 4-4A THUR 4-4D.dwg, 4-4D


Tts
Proposed Spillway
Qal
Qls
Zone of sheared and brecciated Franciscan rocks
Qls
TP-19
Qls
Extensive weathering to tafoni and corestones
90°/140°
Qls
Qls
TP-4
CB-3
Break in slope
Tts
CB-2
Tts shattered
Qls
Tts
TP-1
Fm
Qls
Proposed Dam Axis (Crest El. 778)
Tts
Tts Float
42
Fm
CB-5
CB-6
CB-24
Talus
CB-7
Debris fans
Weathered massive
Fm
Possible Quarry fault trace location
Tts
50
40
55
Talus apron
TP-2
Bench in l.s. mass
Qls
Fm
TP-3
Qls
CB-21
TP-12
BA-8
BA-9
Qls
BA-11
Fm
Qls
Talus
Tts
Qls
CB-22
Proposed Dam Outline
Fm
Fm
Fm
Sheared Franciscan 90°/145°
Fm
Qls
Existing Spillway
CB-20
60
70
TP-11
Fm
Fm
Quarry Fault
Tts
Tts Float
Tts
Fault-controlled (?) topographic bench
Existing Dam
Haf
Qls
Fm
Slump
Qls
Fm
Qls
Fm
Qls
Fm
Fsp
Fm
Existing Outlet Tower
Calaveras Reservoir
SURVEY NORTH
N

NOTE:
LEGEND ON FIGURE 4-4B

100' 0' 100' 200' 400'
1" = 200'

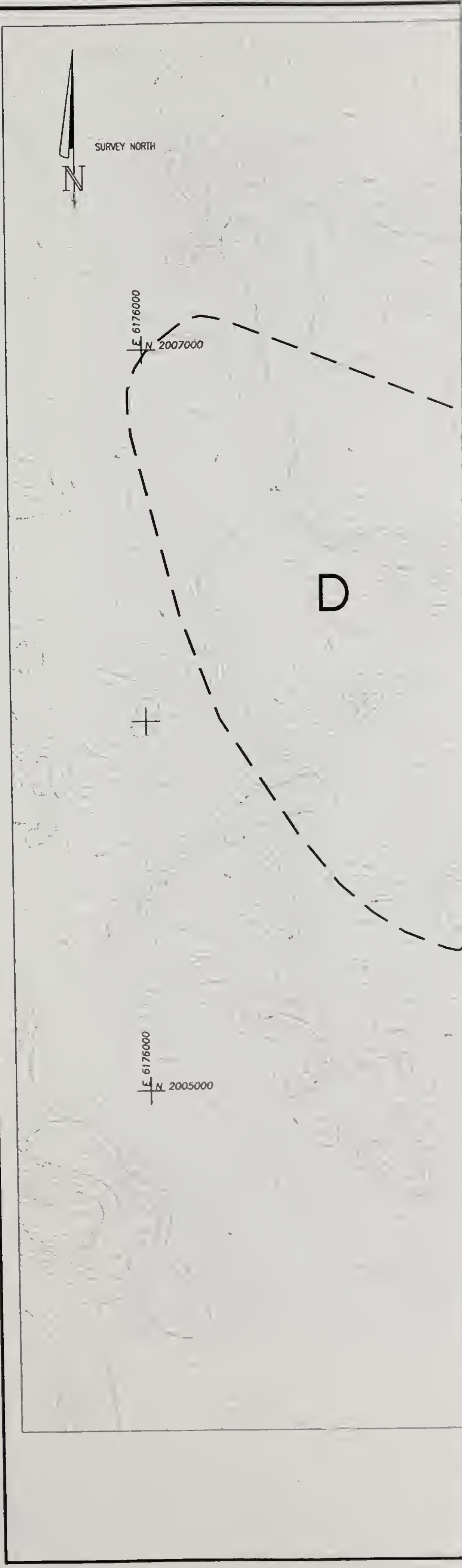
SHEET INDEX

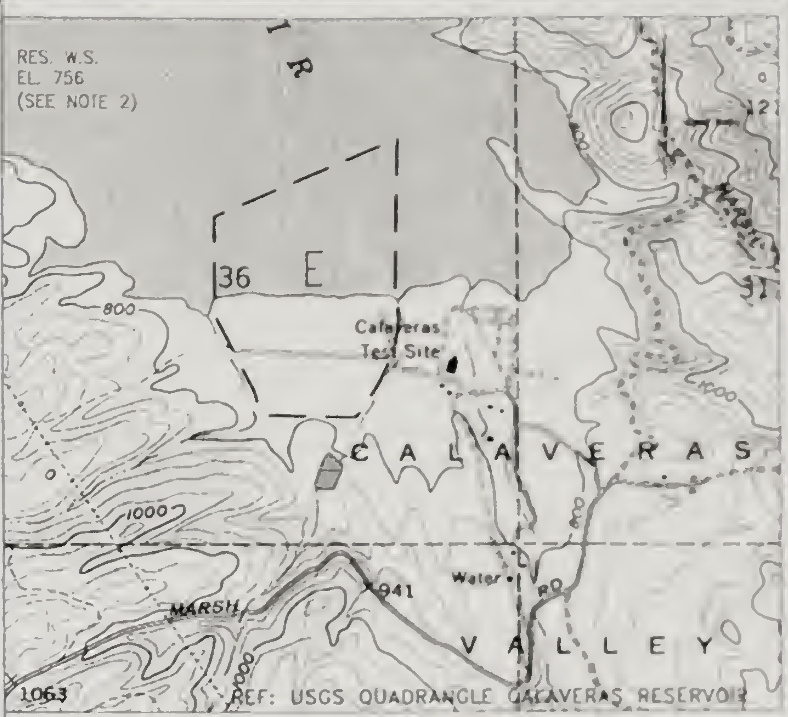
Project No. 26814817

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716

GEOLOGIC AND EXPLORATION LOCATION PLAN
CALAVERAS DAM SITE

FIGURE
4-4D


SURVEY NORTH
N
E 6176000
N 2007000
D
E 6176000
N 2005000


RES. W.S.
EL. 756
(SEE NOTE 2)
R
36
E
800
12
31
Calaveras
Test Site
CALAVERAS
1000
MARSH
941
Water
RD
VALLEY
1063
REF: USGS QUADRANGLE CALAVERAS RESERVOIR

INSET: BORROW AREA E
SCALE 1" = 2,000'

1000' 0' 1000' 2000'
SCALE 1" = 2000'

LEGEND:

— — —	ESTIMATED LIMITS OF BORROW AREA
A	OBSERVATION HILL (TEMBLOR SANDSTONE)
B1	HILL 1000 (TEMBLOR SANDSTONE)
B2	HILL 1000 (BLUESCHIST)
C1	(COLLUVIUM)
C2	(COLLUVIUM)
D	(COLLUVIUM)
E	SOUTH OF RESERVOIR (ALLUVIUM)

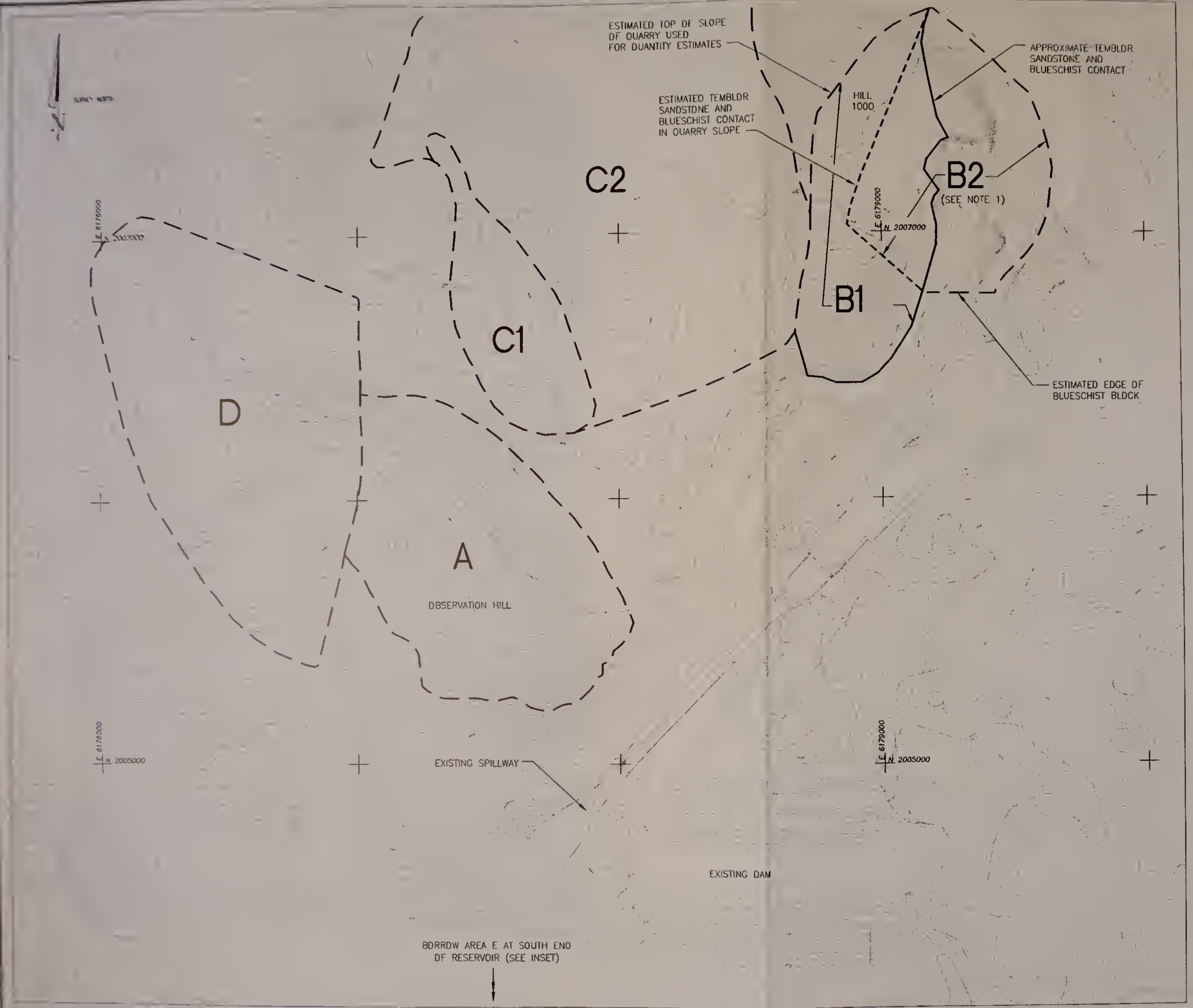
NOTES:

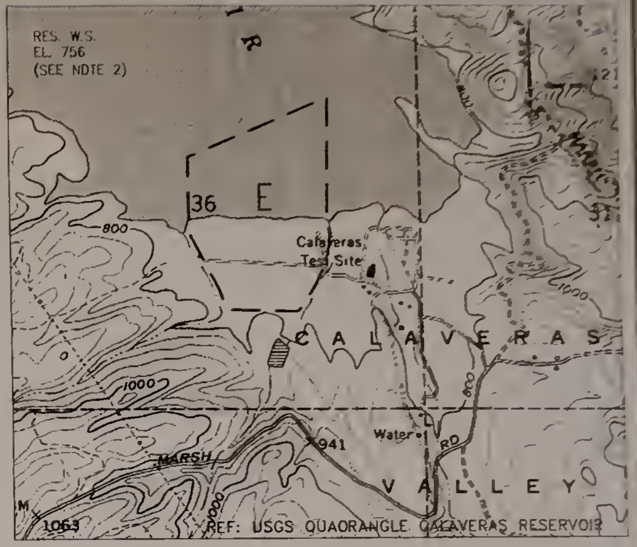
1. BORROW AREA B2 EXTENDS BENEATH B1 (TEMBLOR SANDSTONE).
2. RESTRICTED RESERVOIR WATER SURFACE AT APPROXIMATELY ELEVATION 700.

LIMITS OF POTENTIAL BORROW AREAS
PLAN

FIGURE
4-5

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\4-5 .dwg, 4-5


SURVEY NORTH
N
ESTIMATED TOP OF SLOPE OF QUARRY USED FOR QUANTITY ESTIMATES
ESTIMATED TEMBLOR SANDSTONE AND BLUESCHIST CONTACT IN QUARRY SLOPE
HILL 1000
APPROXIMATE TEMBLOR SANDSTONE AND BLUESCHIST CONTACT
B2
(SEE NOTE 1)
B1
C2
C1
D
A
OBSERVATION HILL
ESTIMATED EDGE OF BLUESCHIST BLOCK
E 6176000
N 2007000
E 6179000
N 2007000
E 6176000
N 2005000
E 6179000
N 2005000
EXISTING SPILLWAY
EXISTING DAM
BORROW AREA E AT SOUTH END OF RESERVOIR (SEE INSET)


RES. W.S.
EL. 756
(SEE NOTE 2)
R
36
E
800
1000
Calaveras Test Site
C A L A V E R A S
V A L L E Y
MARSH
941
Water
RD
1063
M
REF: USGS QUADRANGLE CALAVERAS RESERVOIR

INSET: BORROW AREA E
SCALE: 1" = 2,000'

1000' 0' 1000' 2000'
SCALE: 1"= 2000'

LEGEND:

— — —	ESTIMATED LIMITS OF BORROW AREA
A	OBSERVATION HILL (TEMBLOR SANDSTONE)
B1	HILL 1000 (TEMBLOR SANDSTONE)
B2	HILL 1000 (BLUESCHIST)
C1	(COLLUVIUM)
C2	(COLLUVIUM)
D	(COLLUVIUM)
E	SOUTH OF RESERVOIR (ALLUVIUM)

NOTES:

1. BORROW AREA B2 EXTENDS BENEATH B1 (TEMBLOR SANDSTONE).
2. RESTRICTED RESERVOIR WATER SURFACE AT APPROXIMATELY ELEVATION 700.

200' 0' 200' 400'
SCALE: 1"=400'

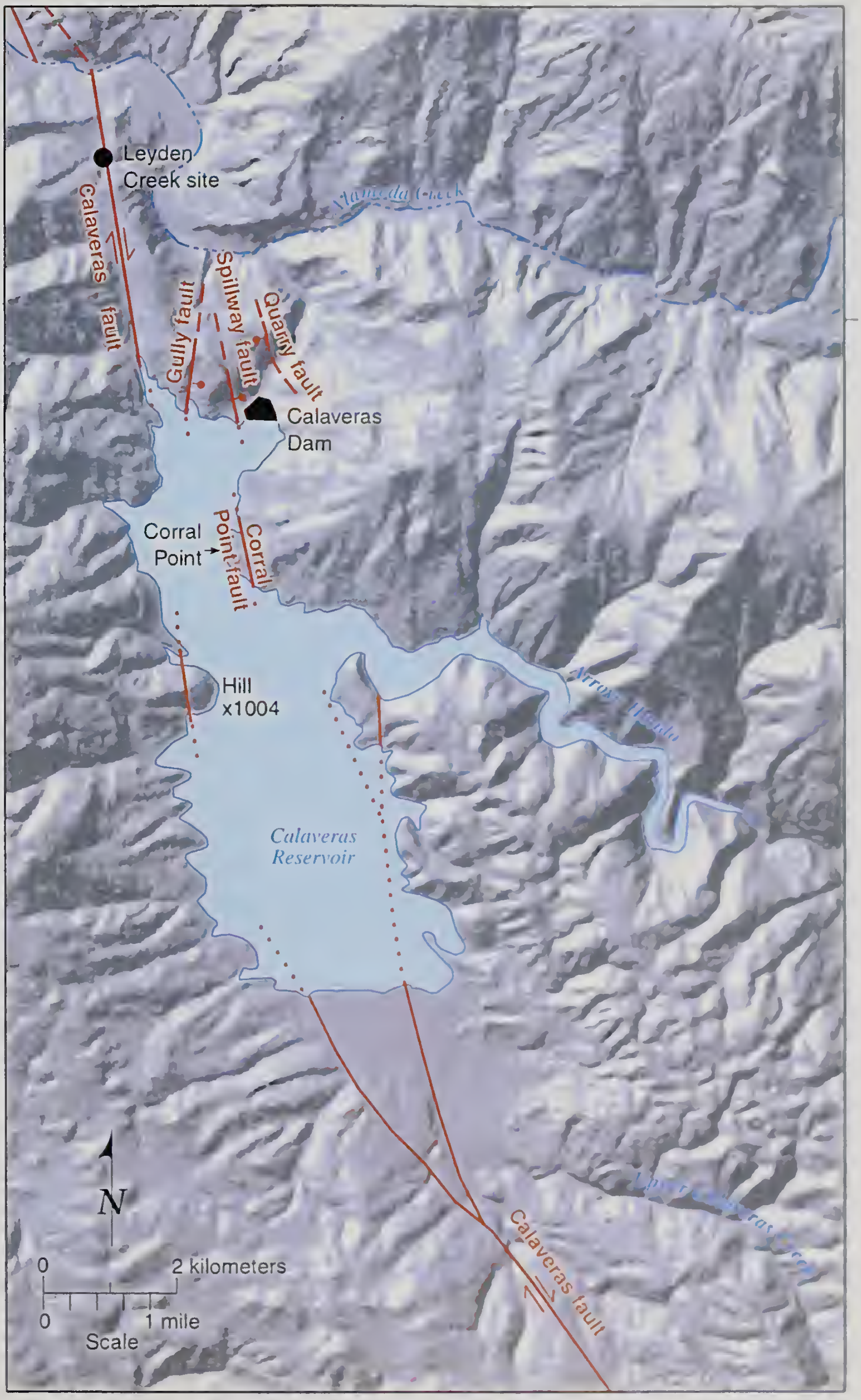
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

LIMITS OF POTENTIAL BORROW AREAS
PLAN

FIGURE
4-5

A:\SHARLD\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\4-5.dwg

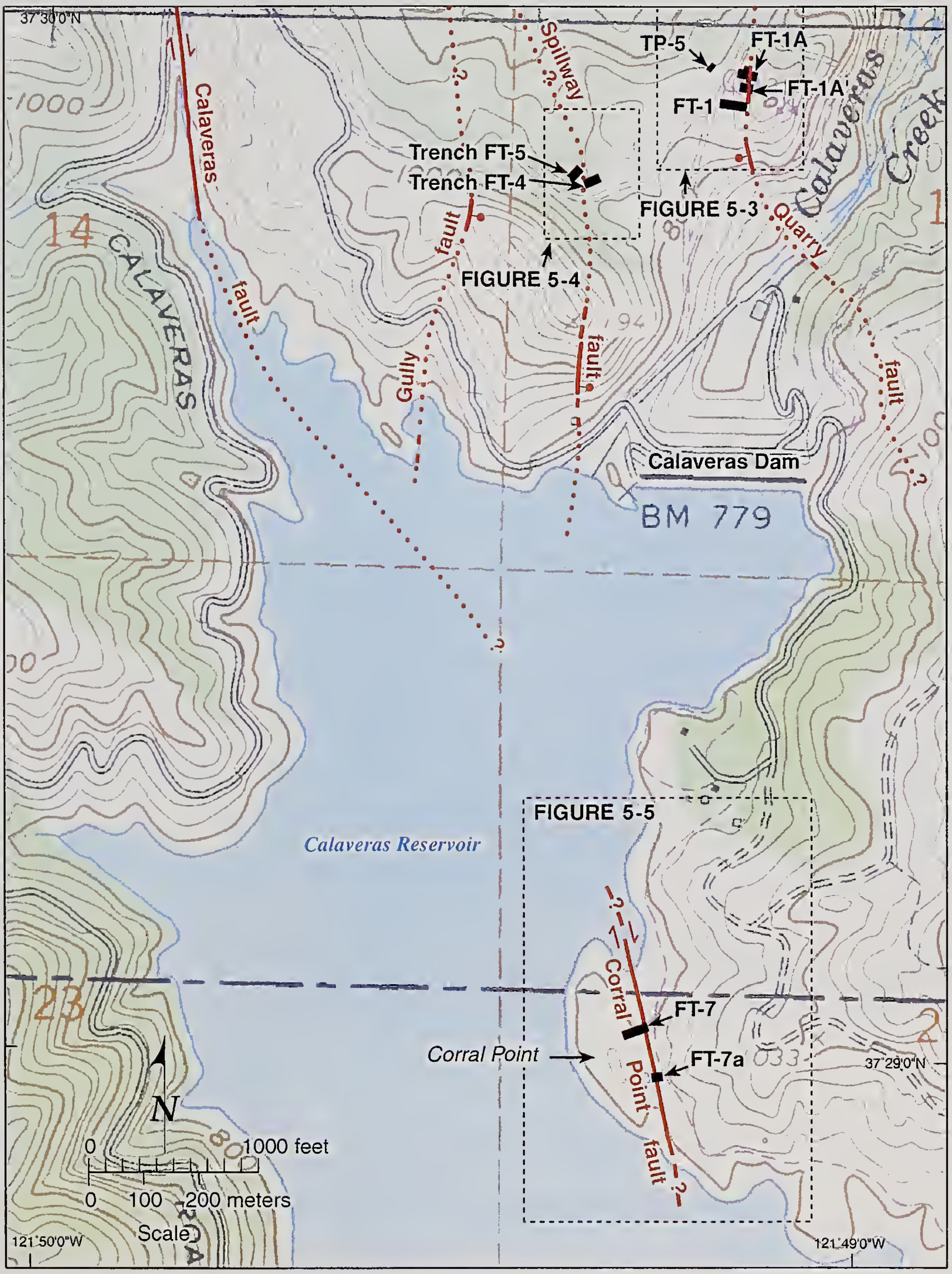

Leyden Creek site
Alameda Creek
Calaveras fault
Gully fault
Spillway fault
Quarry fault
Calaveras Dam
Corral Point
Corral Point fault
Hill x1004
Calaveras Reservoir
Arroyo Hondo
Upper Calaveras Creek
Calaveras fault
N
0
2 kilometers
0
1 mile
Scale

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

FAULTS IN THE
VICINITY OF CALAVERAS RESERVOIR

Figure
5-1


37°30'0"N
TP-5
FT-1A
FT-1A'
FT-1
Spillway
Calaveras
Creek
Calaveras
fault
Trench FT-5
Trench FT-4
FIGURE 5-3
FIGURE 5-4
Quarry
fault
Gully
fault
fault
14
CALAVERAS
1000
794
Calaveras Dam
BM 779
Calaveras Reservoir
FIGURE 5-5
Corral
Point
fault
FT-7
FT-7a
Corral Point
23
2
1
37°29'0"N
N
0
1000 feet
0
100
200 meters
Scale
121°50'0"W
121°49'0"W
?

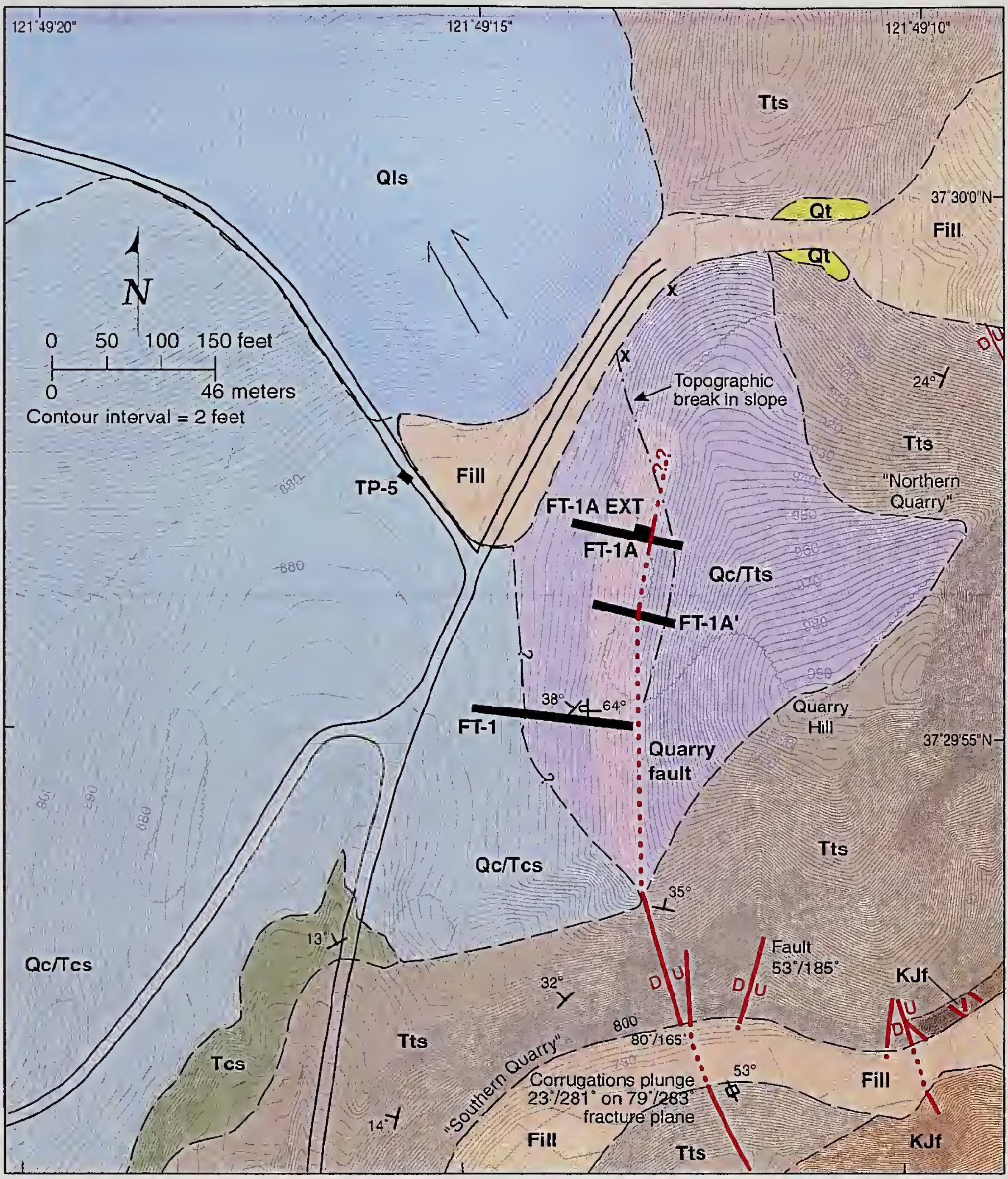
URS

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

LOCATIONS OF IDENTIFIED FAULTS
AND FAULT TRENCHES

Figure
5-2


121°49'20"
121°49'15"
121°49'10"
Tts
Qls
Qt
37°30'0"N
Fill
Qt
N
0 50 100 150 feet
0 46 meters
Contour interval = 2 feet
x
x
Topographic break in slope
24°
Tts
"Northern Quarry"
?-?
TP-5
Fill
FT-1A EXT
FT-1A
Qc/Tts
FT-1A'
Quarry Hill
37°29'55"N
38°
64°
FT-1
Quarry fault
Tts
Qc/Tcs
35°
13°
Fault 53°/185°
KJf
Qc/Tcs
32°
D U
D U
U D
800
80°/165°
Tts
Tcs
"Southern Quarry"
Corrugations plunge 23°/281° on 79°/283° fracture plane
53°
Fill
14°
Fill
Tts
KJf

Explanation

Qls	Quaternary landslide
Qt	Quaternary fluvial deposit
Qc/Tts	Quaternary colluvium covering Temblor Formation
Qc/Tcs	Quaternary colluvium covering Claremont Formation
Tcs	Claremont Formation (shale)
Tts	Temblor Formation (sandstone and shale)
KJf	Franciscan melange
Fill	Fill

FT-1	Trench
TP-5	Test pit
U D	Fault, dotted where concealed (D: down, U: up)
	Fault zone
x	Selected Temblor Formation outcrop
15°	Bedding attitude in bedrock outcrop
64°	Bedding attitude, overturned
	Joint attitude
	Geologic contact, dashed where approximate

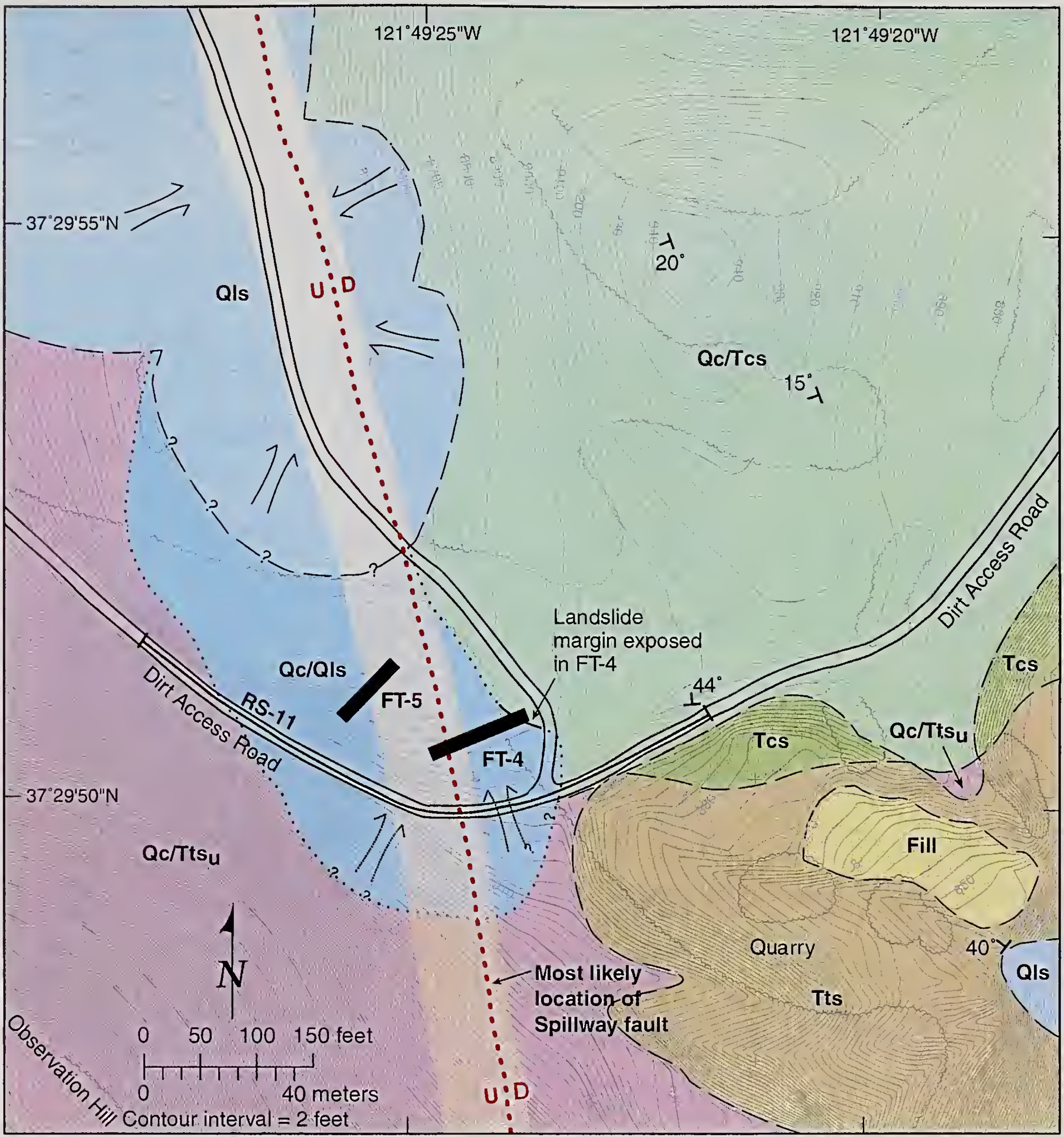
URS

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

GENERALIZED GEOLOGIC MAP OF THE QUARRY FAULT TRENCH SITE

Figure
5-3


121°49'25"W
121°49'20"W
37°29'55"N
37°29'50"N
Qls
U D
20°
Qc/Tcs
15°
Dirt Access Road
Landslide margin exposed in FT-4
44°
Tcs
Qc/Ttsu
Qc/Qls
FT-5
RS-11
FT-4
Dirt Access Road
Fill
Qc/Ttsu
Quarry
40°
Qls
Most likely location of Spillway fault
Tts
N
0 50 100 150 feet
0 40 meters
Observation Hill
Contour interval = 2 feet
U D

Explanation

Fill	Fill
Qc/Qls	Quaternary colluvium covering Qls
Qls	Quaternary landslide
Qc/Ttsu	Quaternary colluvium covering upper Temblor Formation
Qc/Tcs	Quaternary colluvium covering Claremont Formation
Tcs	Claremont Formation (shale)
Tts	Temblor Formation (sandstone and shale)

FT-4 ▬	Trench
• • • U/D • • •	Approximate location of fault (D: down, U: up)
	Zone within which the Spillway fault is interpreted to exist.
15° ⅄	Bedding attitude in bedrock outcrop
RS-11	Seismic refraction line
—?—?—	Geologic contact, dashed where approximate, dotted where obscured/uncertain

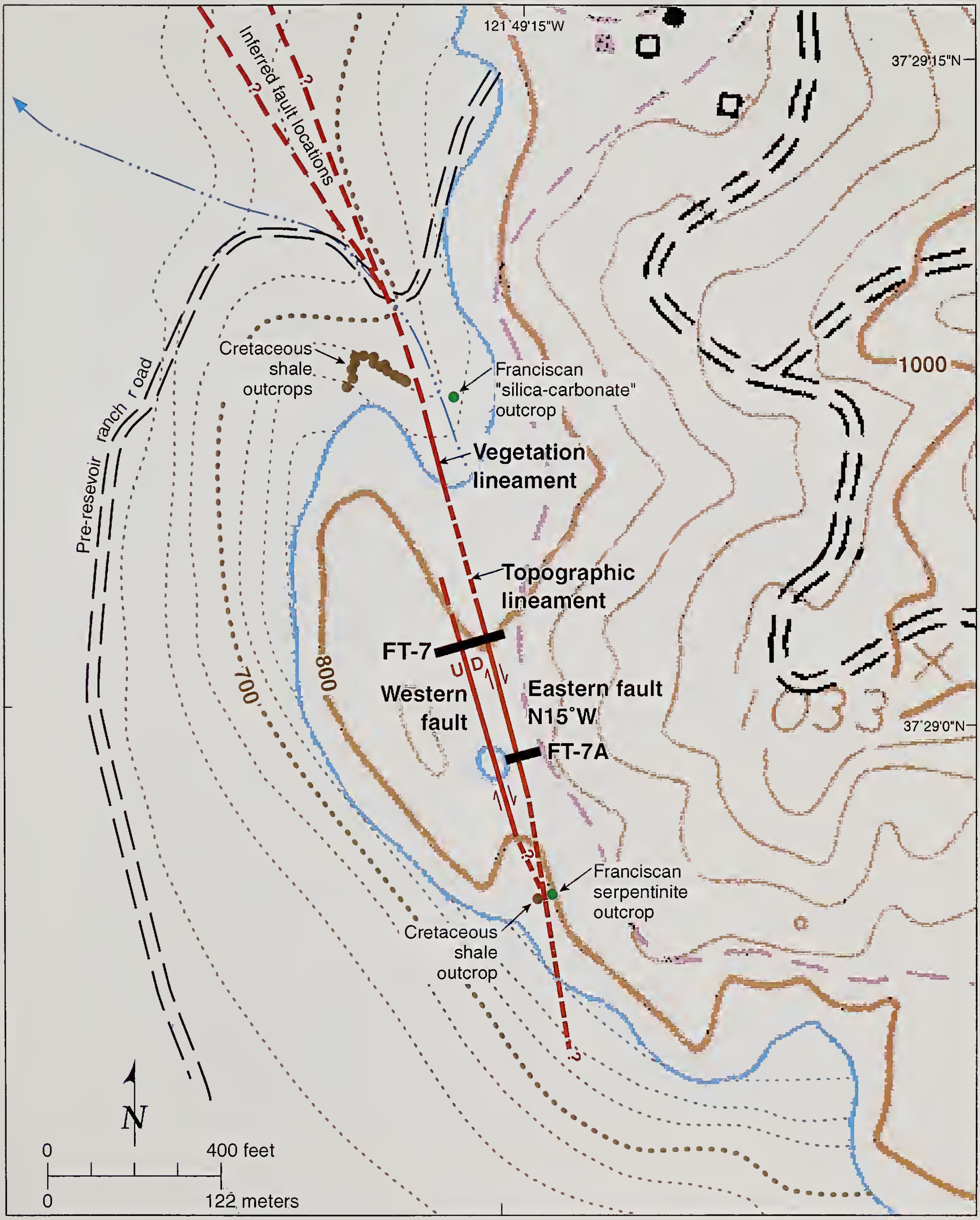
URS

SFPUC Calaveras Dam
Agreement No. CS-716

Project No. 26814817

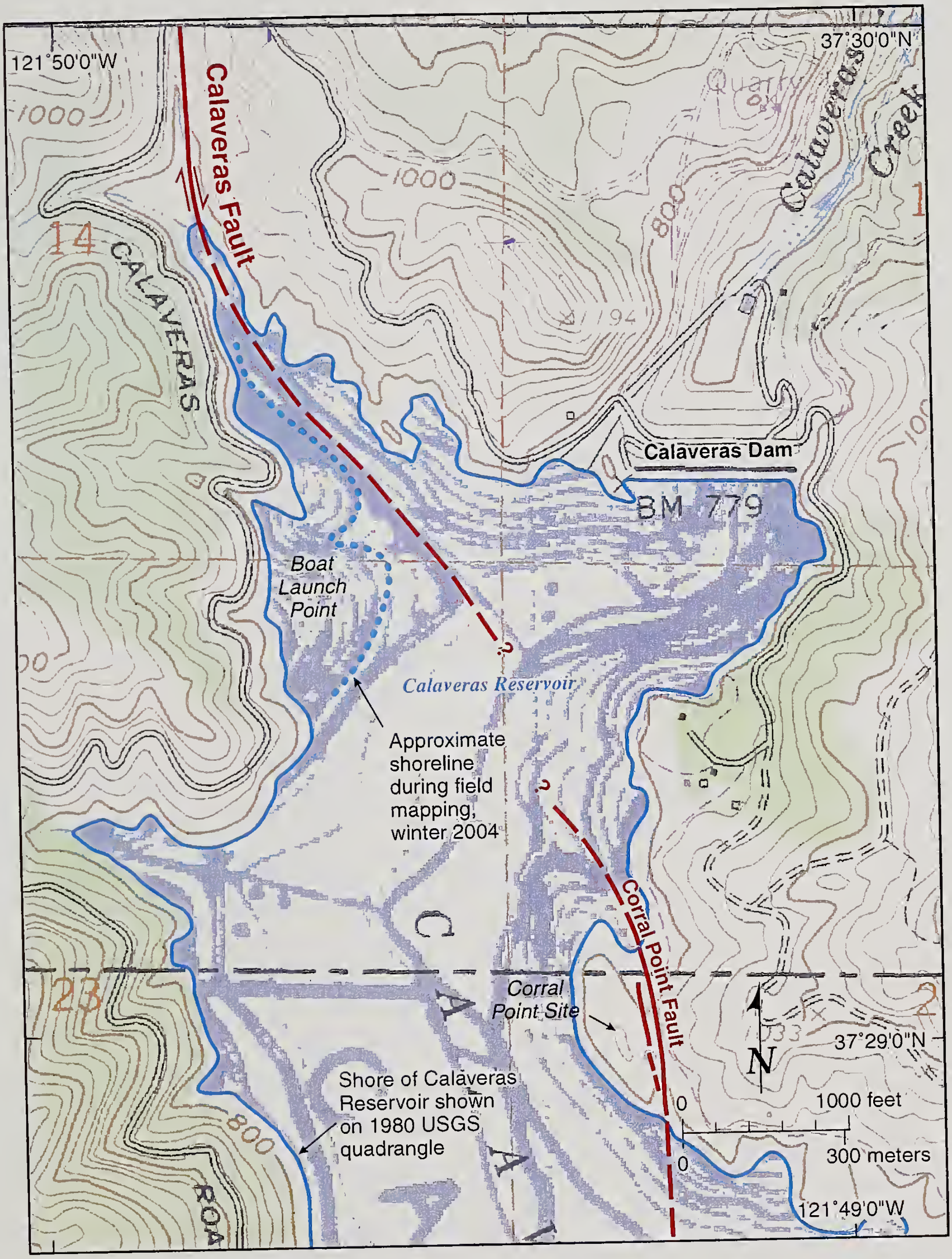
GENERALIZED GEOLOGIC MAP OF THE SPILLWAY FAULT TRENCH SITE

Figure 5-4


121°49'15"W
37°29'15"N
37°29'0"N
Inferred fault locations
?
?
?
Pre-reservoir ranch road
Cretaceous shale outcrops
Franciscan "silica-carbonate" outcrop
Vegetation lineament
Topographic lineament
FT-7
U
D
Western fault
Eastern fault N15°W
FT-7A
700
800
1000
1033
Franciscan serpentinite outcrop
Cretaceous shale outcrop
N
0
400 feet
0
122 meters

Base Map: Calaveras Reservoir 7.5-minute quadrangles above elevation 779 ft.
1899 San Jose 15-minute quadrangle below elevation 779 ft.

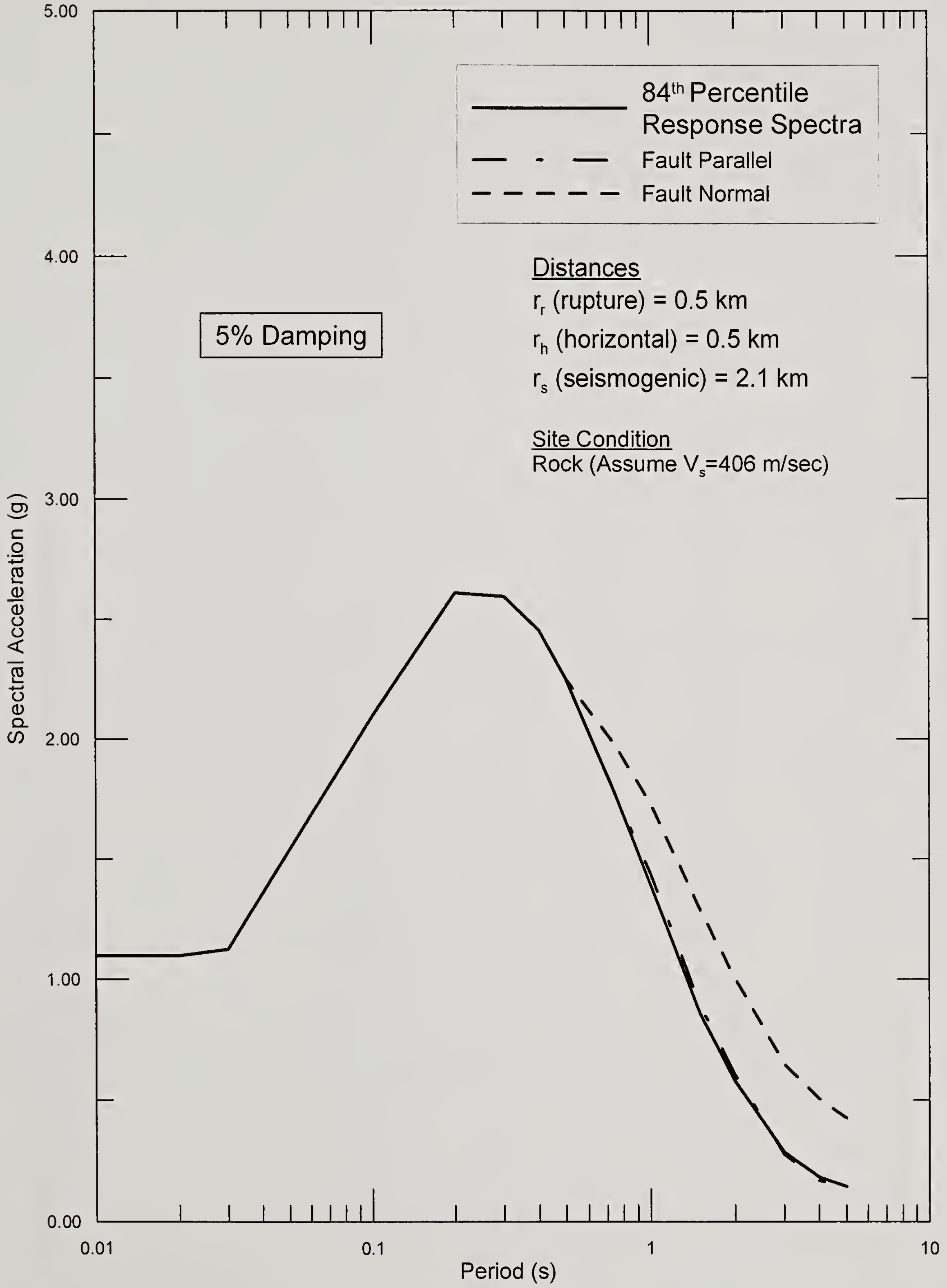
URS	SFPUC Calaveras Dam Agreement No. CS-716 Project No. 26814817	TOPOGRAPHIC MAP OF CORRAL POINT AREA TRENCH SITE	Figure 5-5


121°50'0"W
37°30'0"N
Calaveras Fault
Calaveras Creek
Quarry
1000
800
14
CALAVERAS
1194
Calaveras Dam
BM 779
Boat Launch Point
Calaveras Reservoir
?
Approximate shoreline during field mapping, winter 2004
Corral Point Fault
Corral Point Site
23
N
37°29'0"N
0 1000 feet
0 300 meters
Shore of Calaveras Reservoir shown on 1980 USGS quadrangle
800
ROA
121°49'0"W

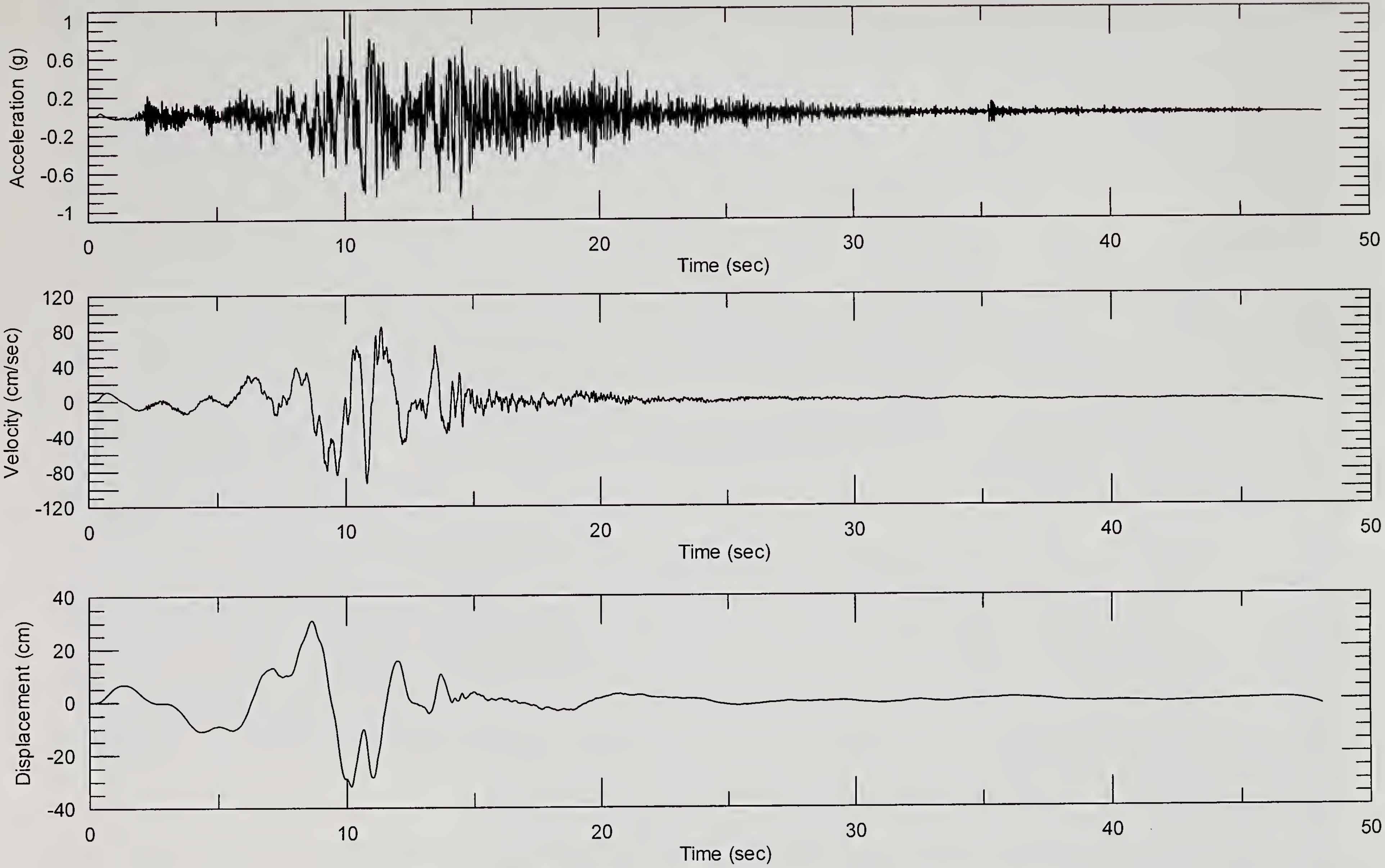
Base Map: Calaveras Reservoir 7.5-minute quadrangle above shoreline
1899 San Jose 15-minute quadrangle below shoreline

CALAVERAS AND CORRAL POINT FAULTS IN THE NORTHERN PART OF CALAVERAS RESERVOIR

Figure 5-6



URS	Project No. 26814817 SFPUC Calaveras Dam Agreement No. CS-716	84th PERCENTILE ACCELERATION RESPONSE SPECTRA FOR THE **M** 7¼ CALAVERAS FAULT MCE ADJUSTED FOR DIRECTIVITY	Figure 6-1



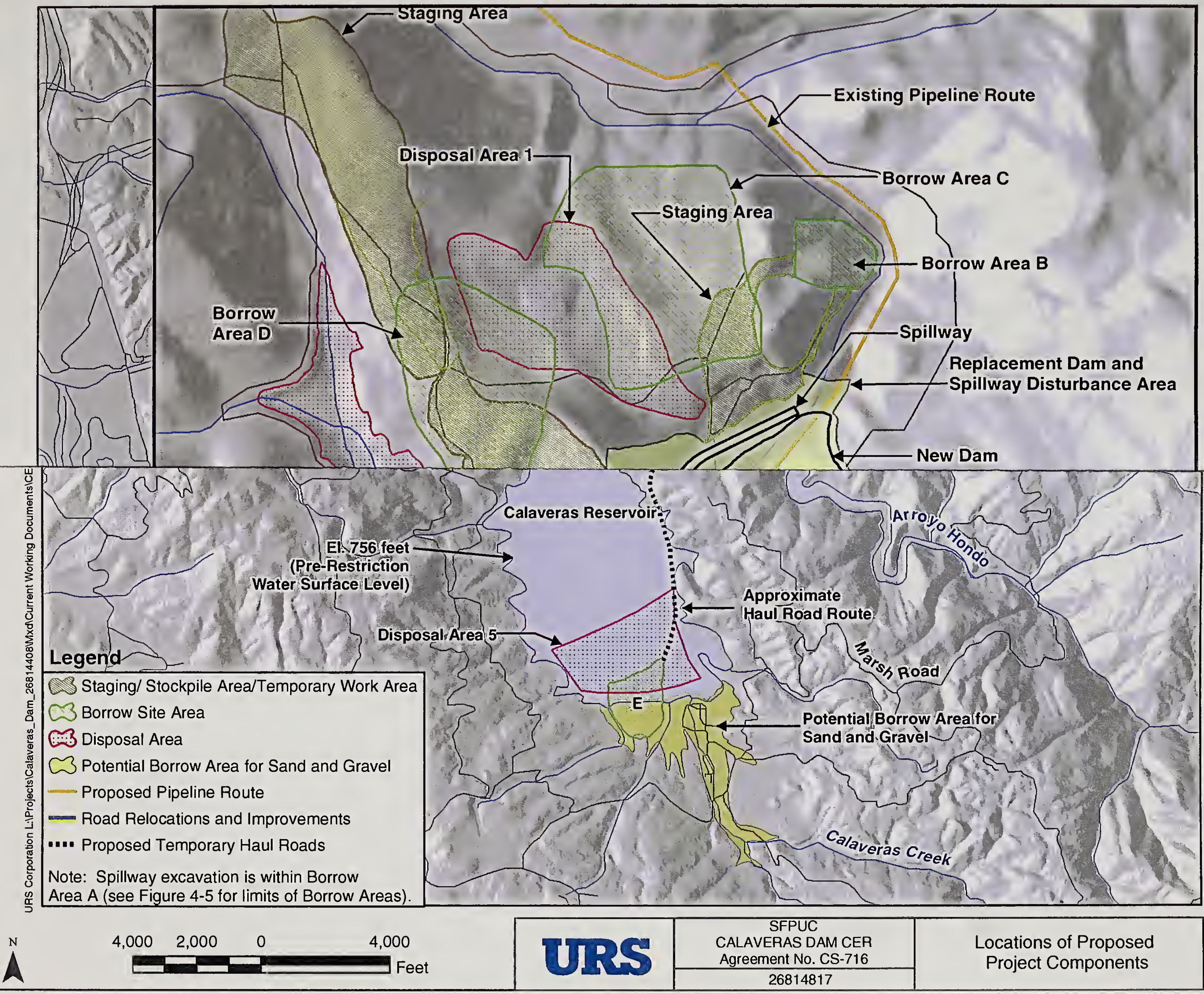
URS

Project No. 26814817

SFPUC
Calaveras Dam
Agreement No. CS-716

RECOMMENDED MCE FAULT PARALLEL
TIME HISTORIES

Figure
6-2


Staging Area
Existing Pipeline Route
Disposal Area 1
Borrow Area C
Staging Area
Borrow Area B
Borrow Area D
Spillway
Replacement Dam and Spillway Disturbance Area
New Dam
Calaveras Reservoir
El. 756 feet (Pre-Restriction Water Surface Level)
Arroyo Hondo
Approximate Haul Road Route
Disposal Area 5
Marsh Road
E
Potential Borrow Area for Sand and Gravel
Calaveras Creek
Legend
Staging/ Stockpile Area/Temporary Work Area
Borrow Site Area
Disposal Area
Potential Borrow Area for Sand and Gravel
Proposed Pipeline Route
Road Relocations and Improvements
Proposed Temporary Haul Roads
URS Corporation L:\Projects\Calaveras_Dam_26814408\Mxd\Current Working Documents\CE
N
4,000
2,000
0
4,000
Feet

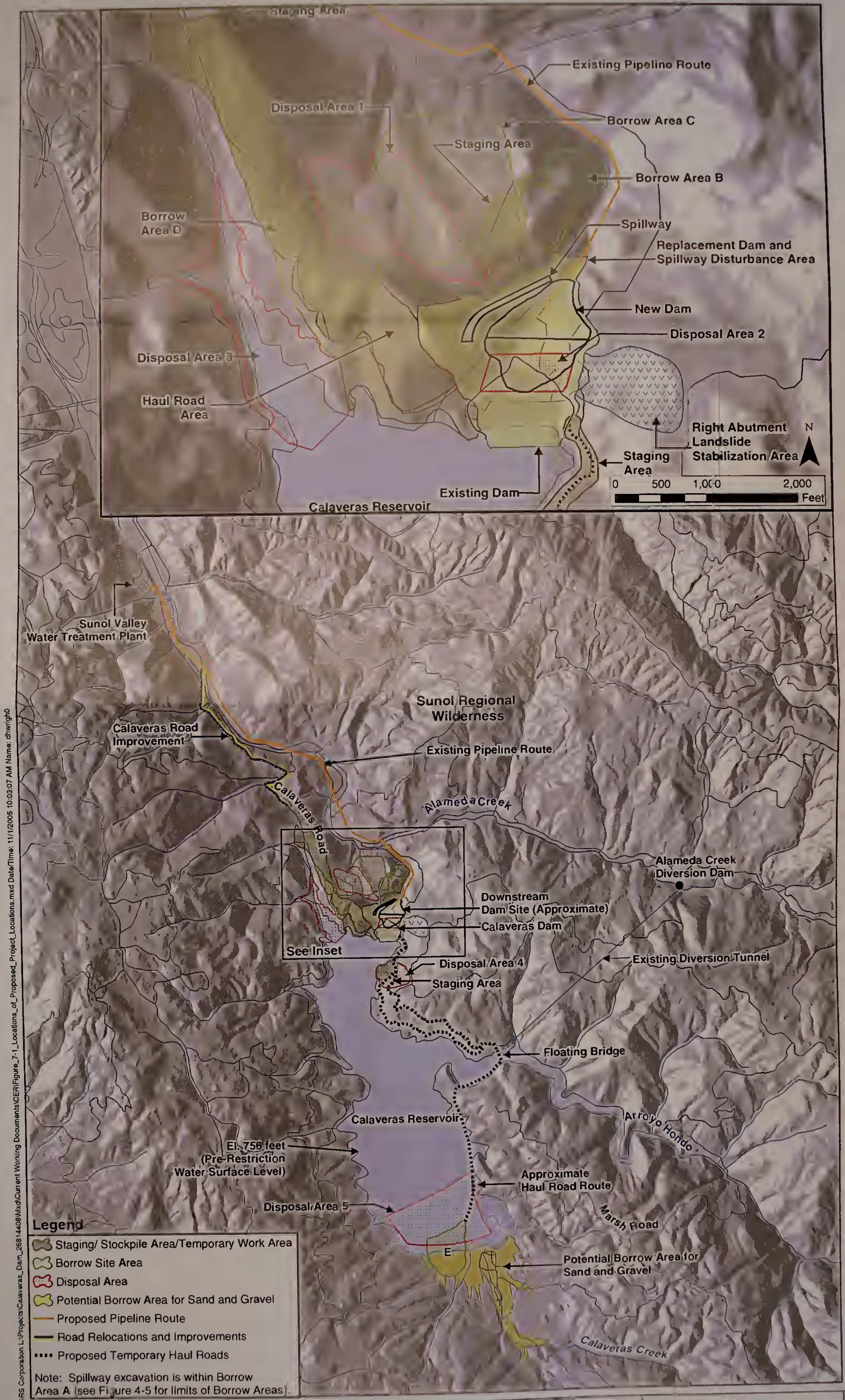
Note: Spillway excavation is within Borrow Area A (see Figure 4-5 for limits of Borrow Areas).

URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Locations of Proposed Project Components

Figure 7-1


Staging Area
Existing Pipeline Route
Disposal Area 1
Borrow Area C
Staging Area
Borrow Area B
Borrow Area D
Spillway
Replacement Dam and Spillway Disturbance Area
New Dam
Disposal Area 2
Disposal Area 3
Haul Road Area
Right Abutment Landslide Stabilization Area
Staging Area
N
0 500 1,000 2,000 Feet
Existing Dam
Calaveras Reservoir
Sunol Valley Water Treatment Plant
Sunol Regional Wilderness
Calaveras Road Improvement
Existing Pipeline Route
Calaveras Road
Alameda Creek
Alameda Creek Diversion Dam
Downstream Dam Site (Approximate)
Calaveras Dam
See Inset
Disposal Area 4
Staging Area
Existing Diversion Tunnel
Floating Bridge
Calaveras Reservoir
Arroyo Hondo
El. 756 feet (Pre-Restriction Water Surface Level)
Approximate Haul Road Route
Marsh Road
Disposal Area 5
E
Potential Borrow Area for Sand and Gravel
Calaveras Creek
Legend
Staging/ Stockpile Area/Temporary Work Area
Borrow Site Area
Disposal Area
Potential Borrow Area for Sand and Gravel
Proposed Pipeline Route
Road Relocations and Improvements
Proposed Temporary Haul Roads
Note: Spillway excavation is within Borrow Area A (see Figure 4-5 for limits of Borrow Areas).
N
4,000 2,000 0 4,000 Feet

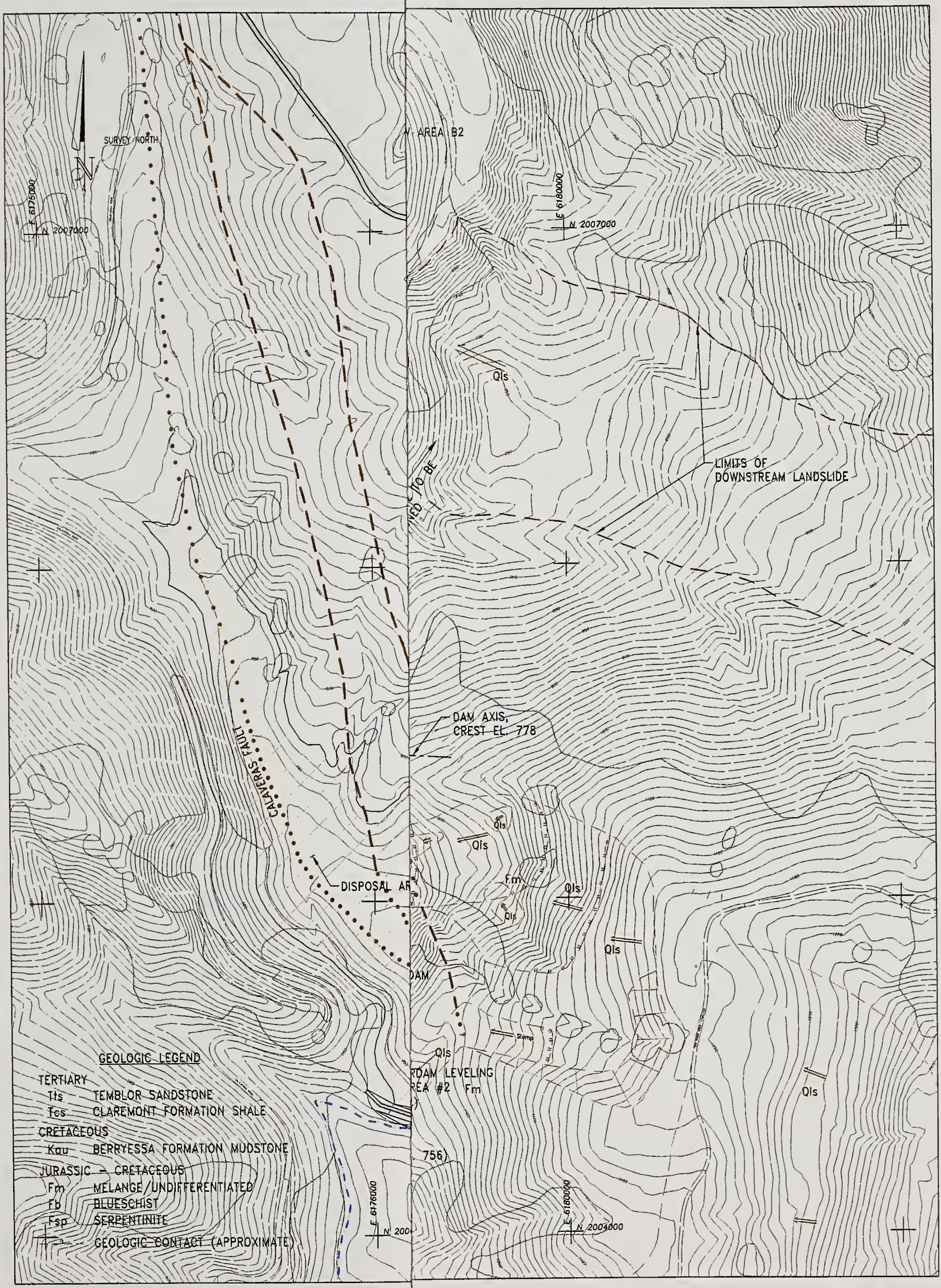
URS Corporation L:\Projects\Calaveras_Dam_26814408\Mxd\Current Working Documents\CER\Figure_7-1_Locations_of_Proposed_Project_Locations.mxd Date/Time: 11/1/2005 10:03:07 AM Name: dhwrigh0

URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Locations of Proposed Project Components

Figure 7-1


SURVEY NORTH
N
E 6175000
N 2007000
AREA B2
E 6180000
N 2007000
Qls
LIMITS OF DOWNSTREAM LANDSLIDE
ED TO BE
DAM AXIS, CREST EL. 778
CALAVERAS FAULT
Qls
Qls
Fm
Qls
Qls
DISPOSAL AR
Qls
DAM
Slump
Qls
RDAM LEVELING
REA #2 Fm
756)
Qls
E 6176000
N 200
E 6180000
N 2003000
GEOLOGIC LEGEND
TERTIARY
Tts TEMBLOR SANDSTONE
Tcs CLAREMONT FORMATION SHALE
CRETACEOUS
Kau BERRYESSA FORMATION MUDSTONE
JURASSIC - CRETACEOUS
Fm MELANGE/UNDIFFERENTIATED
Fb BLUESCHIST
Fsp SERPENTINITE
GEOLOGIC CONTACT (APPROXIMATE)

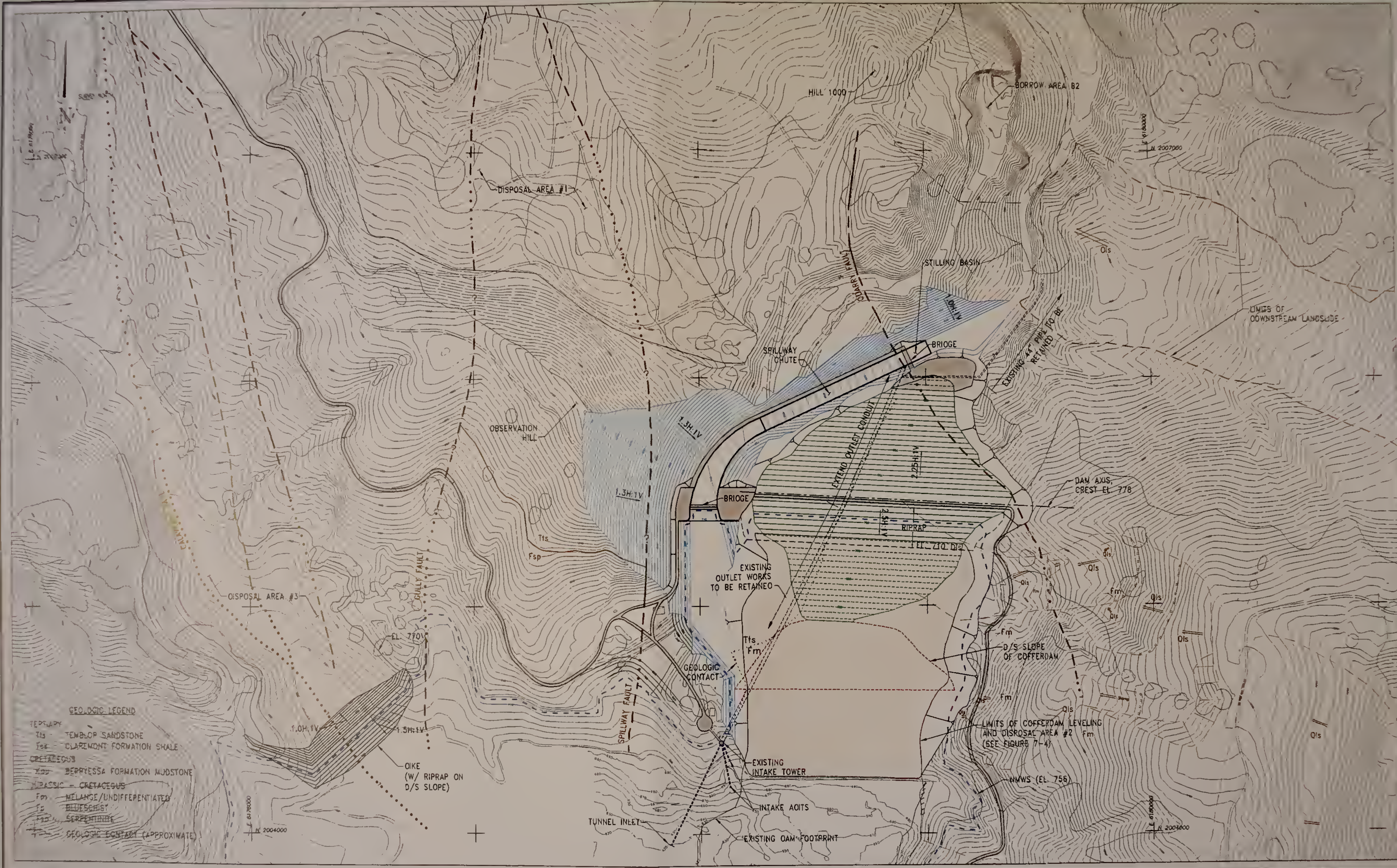
NOTES:

1. BERMS TO BE CONSTRUCTED ON D/S SLOPE OF DAM FOR ACCESS
2. AFTER CONSTRUCTION, REMOVE TOP OF COFFERDAM TO EL. 702 (SEE FIGURE 7-4)

SITE PLAN

FIGURE 7-2

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-2, 7-3, 7-5.dwg, 7-2



HILL 1000
BORROW AREA B2
N 2007000
E 6180000
DISPOSAL AREA #1
STILLING BASIN
QUARRY FAULT
1.0H:1V
LIMITS OF DOWNSTREAM LANDSLIDE
SPILLWAY CHUTE
BRIDGE
EXISTING 44" PIPE TO BE RETAINED
Qls
OBSERVATION HILL
1.3H:1V
EXTEND OUTLET CONDUIT
2.25H:1V
DAM AXIS, CREST EL. 778
BRIDGE
RIPRAP
2.5H:1V
EL. 710 D/S
Tts
Fsp
EXISTING OUTLET WORKS TO BE RETAINED
DISPOSAL AREA #3
GULLY FAULT
EL. 770
Tts
Fm
GEOLOGIC CONTACT
D/S SLOPE OF COFFERDAM
SPILLWAY FAULT
1.0H:1V
1.5H:1V
DIKE (W/ RIPRAP ON D/S SLOPE)
LIMITS OF COFFERDAM LEVELING AND DISPOSAL AREA #2 (SEE FIGURE 7-4)
EXISTING INTAKE TOWER
NMWS (EL. 756)
INTAKE ADITS
TUNNEL INLET
EXISTING DAM FOOTPRINT
E 6176000
N 2004000
E 6180000
N 2004000
GEOLOGIC LEGEND
TERTIARY
Tts - TEMBLOR SANDSTONE
Fsk - CLAREMONT FORMATION SHALE
CRETACEOUS
Kbb - BERRYESSA FORMATION MUDSTONE
JURASSIC - CRETACEOUS
Fm - MELANGE/UNDIFFERENTIATED
Fb - BLUESCHIST
Fsp - SERPENTINITE
GEOLOGIC CONTACT (APPROXIMATE)

NOTES:

1 BERMS TO BE CONSTRUCTED ON O/S SLOPE OF DAM FOR ACCESS

2 AFTER CONSTRUCTION, REMOVE TOP OF COFFERDAM TO EL. 702 (SEE FIGURE 7-4)

200' 0' 200' 400'

SCALE: 1"=400'

URS

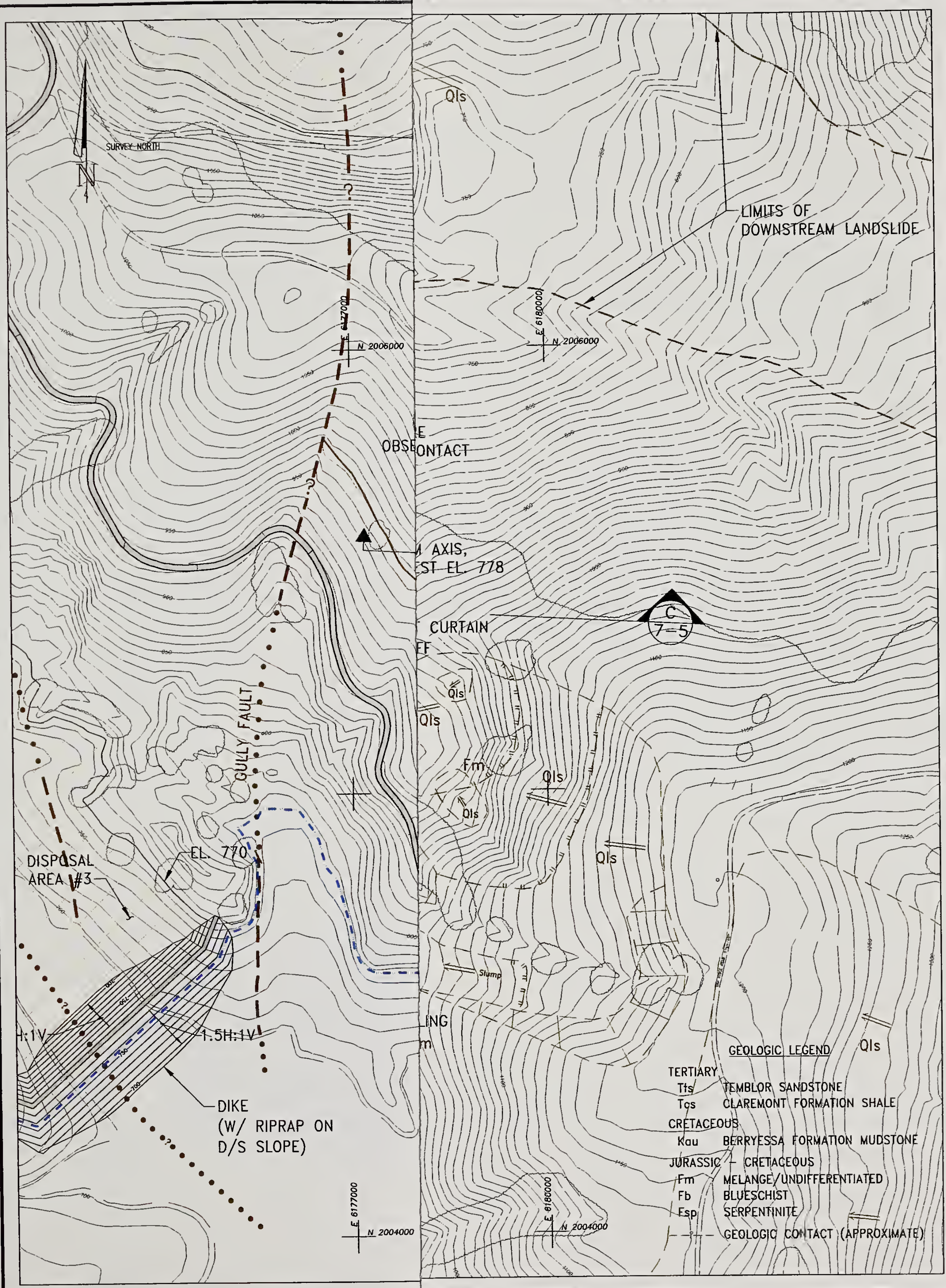
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

SITE PLAN

FIGURE
7-2

J:\CADS\URE D\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CERV7-2, 7-3, 7-6 dwg, 7-2


SURVEY NORTH
N
Qls
LIMITS OF DOWNSTREAM LANDSLIDE
E 6177000
N 2006000
E 6180000
N 2006000
E
OBSE ONTACT
I AXIS,
ST EL. 778
CURTAIN
FF
C
7-5
Qls
Qls
Fm
Qls
Qls
Qls
GULLY FAULT
Slump
DISPOSAL AREA #3
EL. 770
H:1V
1.5H:1V
ING
m
DIKE (W/ RIPRAP ON D/S SLOPE)
E 6177000
N 2004000
E 6180000
N 2004000
Qls
GEOLOGIC LEGEND
TERTIARY
Tts TEMBLOR SANDSTONE
Tcs CLAREMONT FORMATION SHALE
CRETACEOUS
Kau BERRYESSA FORMATION MUDSTONE
JURASSIC - CRETACEOUS
Fm MELANGE/UNDIFFERENTIATED
Fb BLUESCHIST
Fsp SERPENTINITE
GEOLOGIC CONTACT (APPROXIMATE)

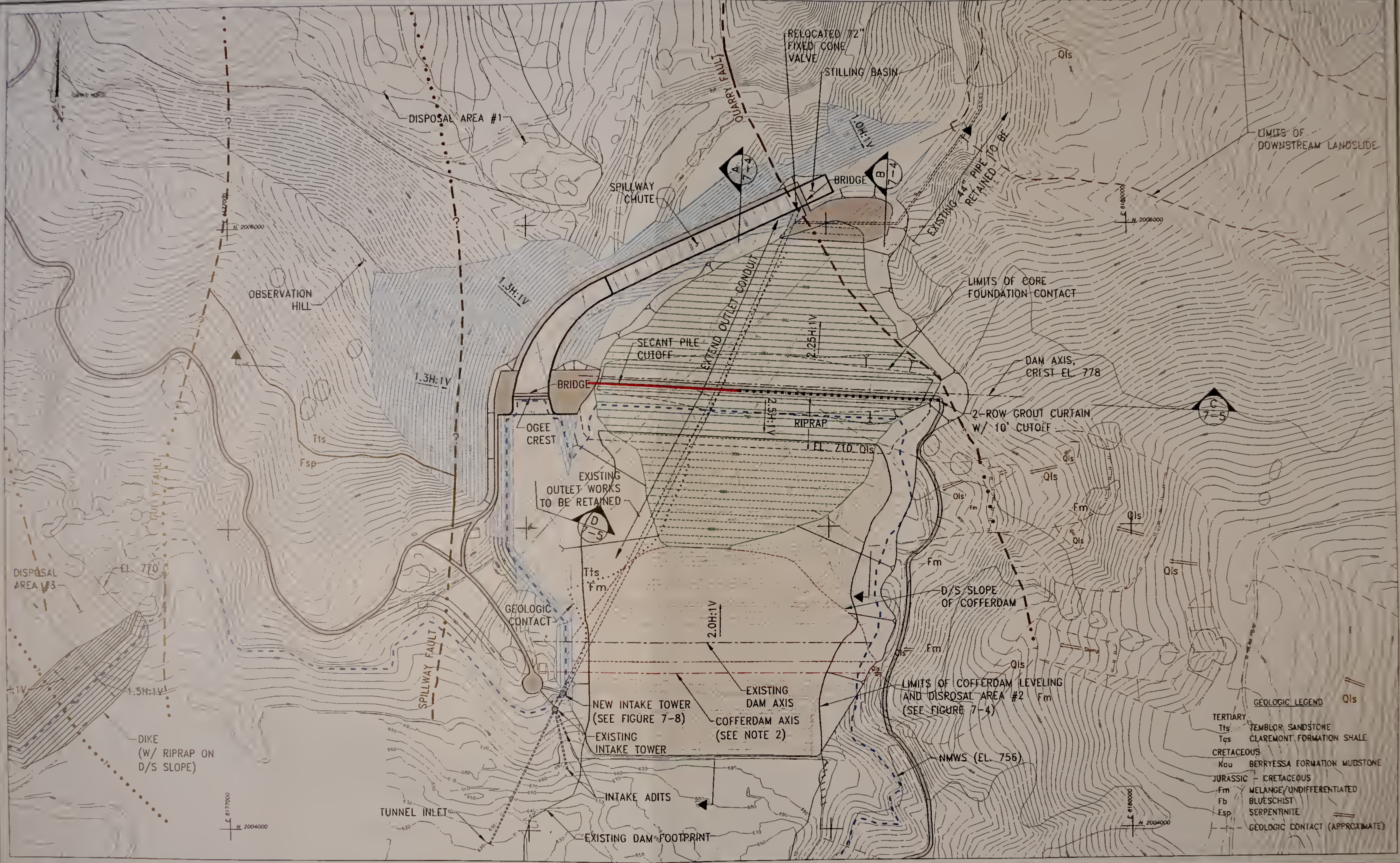
NOTES:

1. BERMS TO BE CONSTRUCTED ON D/S SLOPE OF DAM FOR ACCESS
2. AFTER CONSTRUCTION, REMOVE TOP OF COFFERDAM TO EL. 702 (SEE FIGURE 7-4)

EMBANKMENT DAM AND SPILLWAY PLAN

FIGURE 7-3

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-2, 7-3, 7-5.dwg, 7-3


RELOCATED 72" FIXED CONE VALVE
STILLING BASIN
QUARRY FAULT
1.0H:1V
BRIDGE
EXISTING 44" PIPE TO BE RETAINED
Qls
LIMITS OF DOWNSTREAM LANDSLIDE
DISPOSAL AREA #1
SPILLWAY CHUTE
N 2006000
OBSERVATION HILL
1.3H:1V
LIMITS OF CORE FOUNDATION CONTACT
EXTEND OUTLET CONDUIT
SECANT PILE CUTOFF
2.25H:1V
DAM AXIS, CREST EL. 778
1.3H:1V
BRIDGE
2-ROW GROUT CURTAIN W/ 10' CUTOFF
OGEE CREST
2.5H:1V
RIPRAP
EL. 710
Tts
Fsp
EXISTING OUTLET WORKS TO BE RETAINED
GULLY FAULT
Fm
DISPOSAL AREA #3
EL. 770
GEOLOGIC CONTACT
D/S SLOPE OF COFFERDAM
2.0H:1V
SPILLWAY FAULT
1.5H:1V
DIKE (W/ RIPRAP ON D/S SLOPE)
NEW INTAKE TOWER (SEE FIGURE 7-8)
EXISTING INTAKE TOWER
EXISTING DAM AXIS
COFFERDAM AXIS (SEE NOTE 2)
LIMITS OF COFFERDAM LEVELING AND DISPOSAL AREA #2 (SEE FIGURE 7-4)
NMWS (EL. 756)
INTAKE ADITS
TUNNEL INLET
EXISTING DAM FOOTPRINT
N 2004000
A 7-4
B 7-4
C 7-5
D 7-5
GEOLOGIC LEGEND
Qls
TERTIARY
Tts TEMBLOR SANDSTONE
Tcs CLAREMONT FORMATION SHALE
CRETACEOUS
Kou BERRYESSA FORMATION MUDSTONE
JURASSIC - CRETACEOUS
Fm MELANGE/UNDIFFERENTIATED
Fb BLUESCHIST
Esp SERPENTINITE
GEOLOGIC CONTACT (APPROXIMATE)

NOTES:

1. BERMS TO BE CONSTRUCTED ON O/S SLOPE OF DAM FOR ACCESS
2. AFTER CONSTRUCTION, REMOVE TOP OF COFFERDAM TO EL. 702 (SEE FIGURE 7-4)

150' 0' 150' 300'

SCALE: 1"=300'

URS

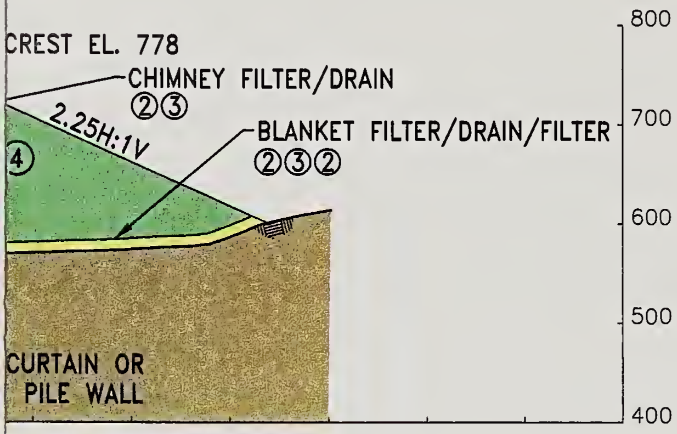
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

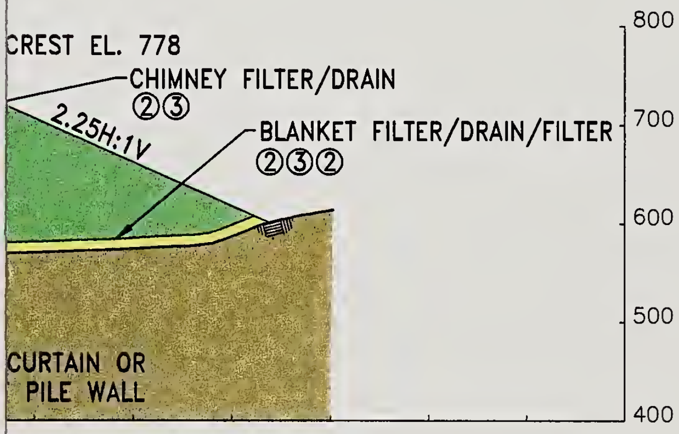
EMBANKMENT DAM AND SPILLWAY PLAN

FIGURE
7-3

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-2, 7-3, 7-5 dwg. 7-3

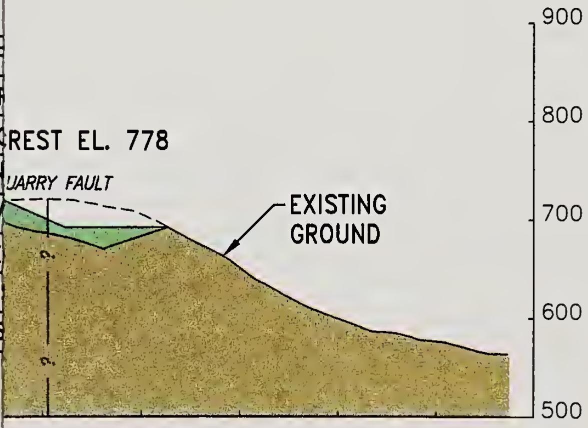

CREST EL. 778
CHIMNEY FILTER/DRAIN
②③
2.25H:1V
④
BLANKET FILTER/DRAIN/FILTER
②③②
CURTAIN OR
PILE WALL
800
700
600
500
400

E OF EXISTING DAM


CREST EL. 778
CHIMNEY FILTER/DRAIN
②③
2.25H:1V
BLANKET FILTER/DRAIN/FILTER
②③②
CURTAIN OR
PILE WALL
800
700
600
500
400

ON

SUMMARY OF		
ZONE	DESCRIPTION	MATER
①	CORE	SANDY TO SILTY
②	FILTER	SAN
③	DRAIN	GRAV
④	SHELL	ROCKY EARTHFILL (TE
⑤	BEDDING	GRAVEL & COBBLE
⑥	RIPRAP	ROCK (BLUESCHIS


CREST EL. 778
UARRY FAULT
EXISTING
GROUND
?
?
900
800
700
600
500

N AT RIGHT ABUTMENT

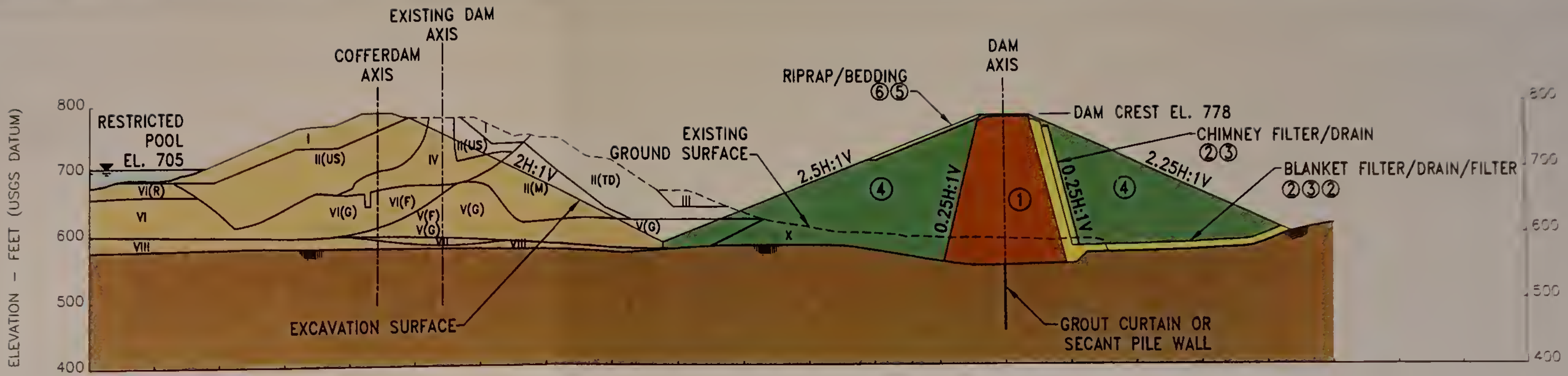
NOTES:

1. SEE FIGURE 2-3 FOR LEGEND TO EX
2. SEE FIGURE 7-6 FOR EMBANKMENT
3. ALLUVIAL DEPOSIT NEAR BORROW ARE
   ALTERNATIVE SOURCE OF FILTER AND

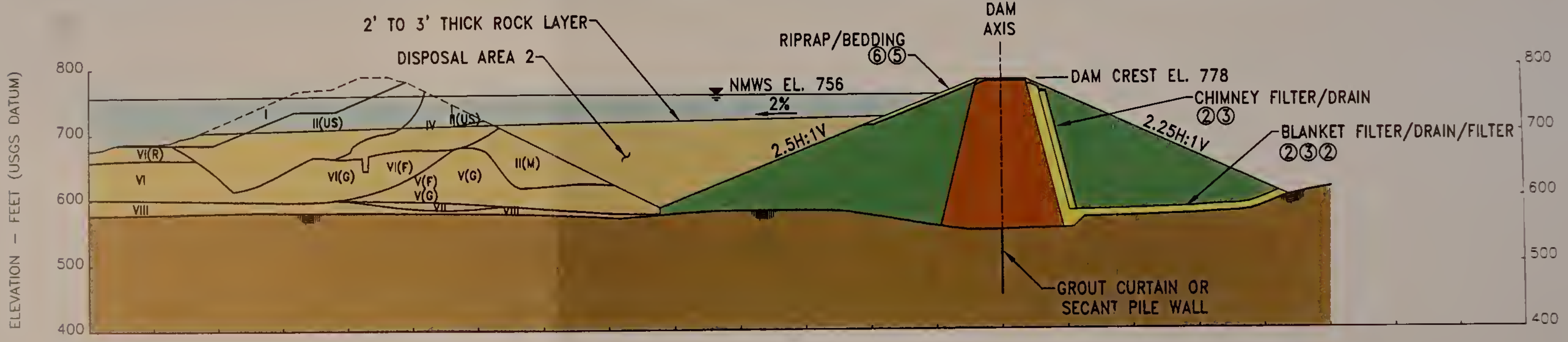
EMBANKMENT DAM SECTIONS

FIGURE
7-4

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-4.dwg, 7-4

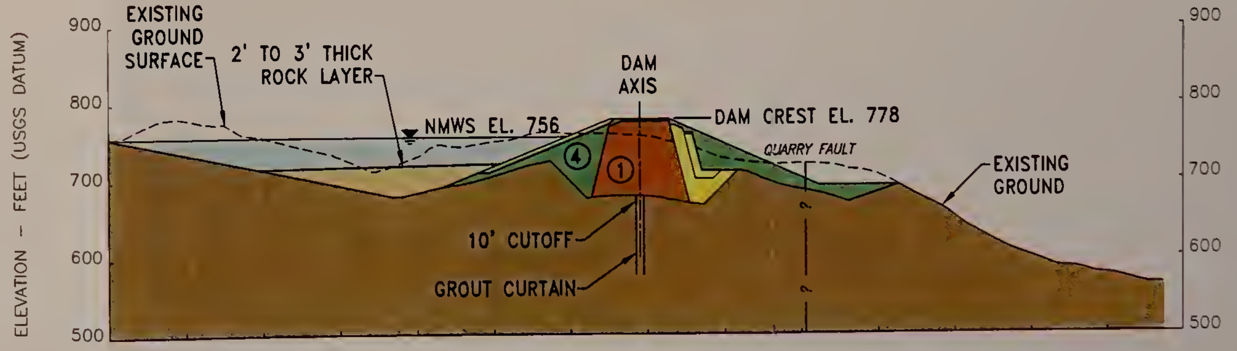

EXISTING DAM AXIS
COFFERDAM AXIS
RIPRAP/BEDDING ⑥⑤
DAM AXIS
800
700
600
500
400
ELEVATION - FEET (USGS DATUM)
RESTRICTED POOL EL. 705
I
II(US)
IV
II(US)
2H:1V
II(TD)
II(M)
III
VI(R)
VI
VI(G)
VI(F)
V(F)
V(G)
V(G)
V(G)
VII
VIII
VIII
EXISTING GROUND SURFACE
X
2.5H:1V
④
0.25H:1V
①
0.25H:1V
④
2.25H:1V
DAM CREST EL. 778
CHIMNEY FILTER/DRAIN ②③
BLANKET FILTER/DRAIN/FILTER ②③②
EXCAVATION SURFACE
GROUT CURTAIN OR SECANT PILE WALL

SECTION (A/7-3) – EMBANKMENT MAXIMUM SECTION AND EXCAVATION OF DOWNSTREAM FACE OF EXISTING DAM


2' TO 3' THICK ROCK LAYER
DISPOSAL AREA 2
RIPRAP/BEDDING ⑥⑤
DAM AXIS
NMWS EL. 756
2%
DAM CREST EL. 778
CHIMNEY FILTER/DRAIN ②③
2.25H:1V
BLANKET FILTER/DRAIN/FILTER ②③②
2.5H:1V
800
700
600
500
400
ELEVATION - FEET (USGS DATUM)
I
II(US)
IV
II(US)
II(M)
VI(R)
VI
VI(G)
VI(F)
V(F)
V(G)
V(G)
VII
VIII
VIII
GROUT CURTAIN OR SECANT PILE WALL

SECTION (A/7-3) – EMBANKMENT MAXIMUM SECTION AT PROJECT COMPLETION

SUMMARY OF EMBANKMENT DAM ZONES			
ZONE	DESCRIPTION	MATERIAL	SOURCE
①	CORE	SANDY TO SILTY CLAY (ALLUVIUM)	BORROW AREA E
②	FILTER	SAND	IMPORT (SEE NOTE 3)
③	DRAIN	GRAVEL	IMPORT (SEE NOTE 3)
④	SHELL	ROCKY EARTHFILL (TEMBLOR SANDSTONE)	SPILLWAY EXCAVATION
⑤	BEDDING	GRAVEL & COBBLES OR FINE ROCK	IMPORT OR BORROW AREA B2
⑥	RIPRAP	ROCK (BLUESCHIST/GRAYWACKE)	BORROW AREA B2 AND EXIST. DAM


900
800
700
600
500
ELEVATION - FEET (USGS DATUM)
EXISTING GROUND SURFACE
2' TO 3' THICK ROCK LAYER
NMWS EL. 756
DAM AXIS
DAM CREST EL. 778
QUARRY FAULT
④
①
EXISTING GROUND
10' CUTOFF
GROUT CURTAIN
?
?

SECTION (B/7-3) – TYPICAL EMBANKMENT SECTION AT RIGHT ABUTMENT

NOTES:

1. SEE FIGURE 2-3 FOR LEGEND TO EXISTING DAM ZONES
2. SEE FIGURE 7-6 FOR EMBANKMENT DETAILS
3. ALLUVIAL DEPOSIT NEAR BORROW AREA E IS A POTENTIAL ALTERNATIVE SOURCE OF FILTER AND DRAIN MATERIAL

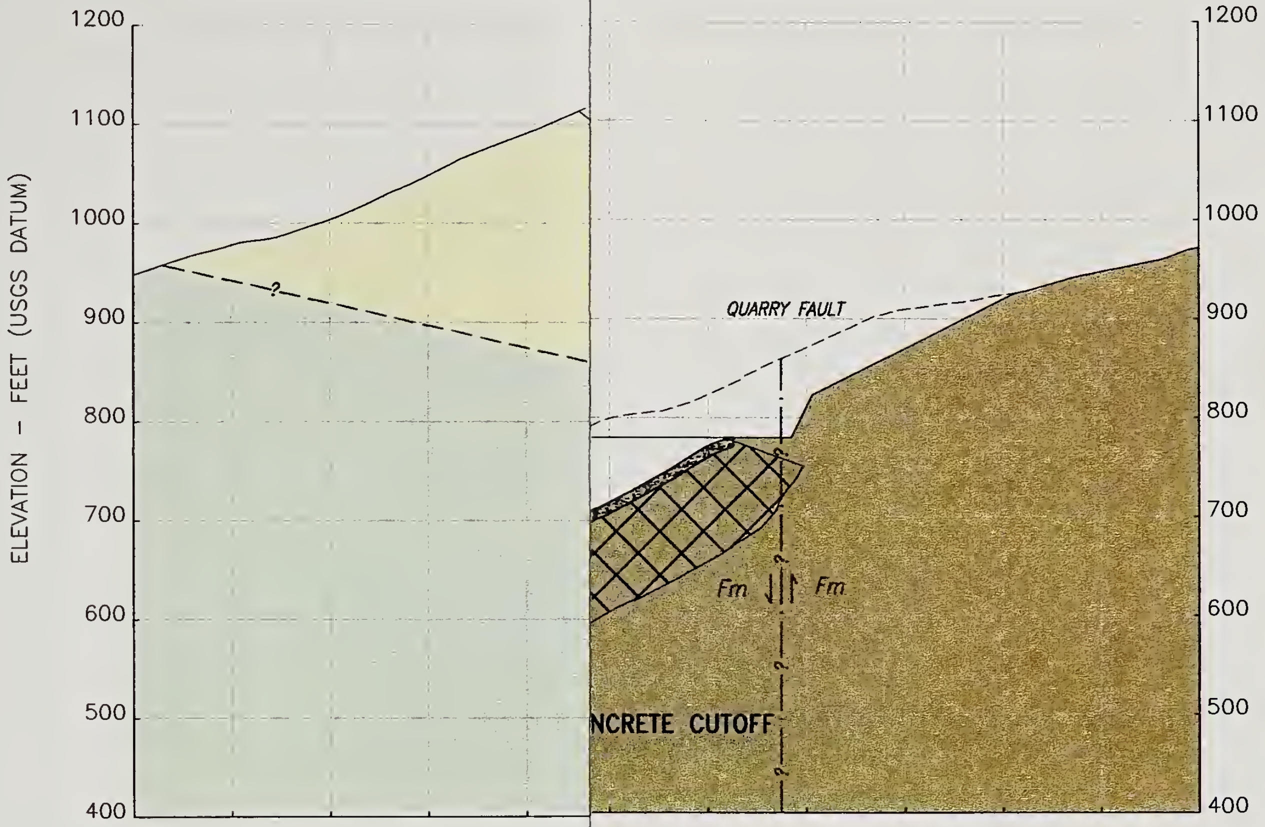
100' 0 100' 200'
SCALE: 1"=200'

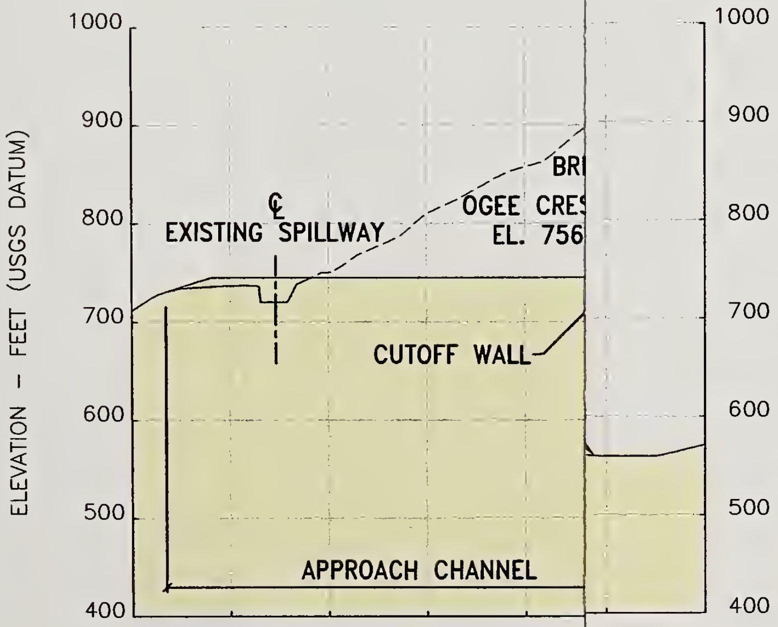
URS

Project No. 26814817
SFPUC
CALAVERAS DAM
Agreement No. CS-716

EMBANKMENT DAM SECTIONS

FIGURE 7-4


1200
1100
1000
900
800
700
600
500
400
ELEVATION - FEET (USGS DATUM)
?
QUARRY FAULT
Fm
Fm
?
?
?
NCRETE CUTOFF
1200
1100
1000
900
800
700
600
500
400


1000
900
800
700
600
500
400
ELEVATION - FEET (USGS DATUM)
℄
EXISTING SPILLWAY
BRI
OGEE CRES
EL. 756
CUTOFF WALL
APPROACH CHANNEL
1000
900
800
700
600
500
400

GEOLOGIC LEGEND

TERTIARY	
Tts	TEMBLOR SANDSTONE
JURASSIC –	CRETACEOUS
Fm	MELANGE/UNDIFFERENTIATED
Fsp	SERPENTINITE
—?—	GEOLOGIC CONTACT (APPROXIMATE)

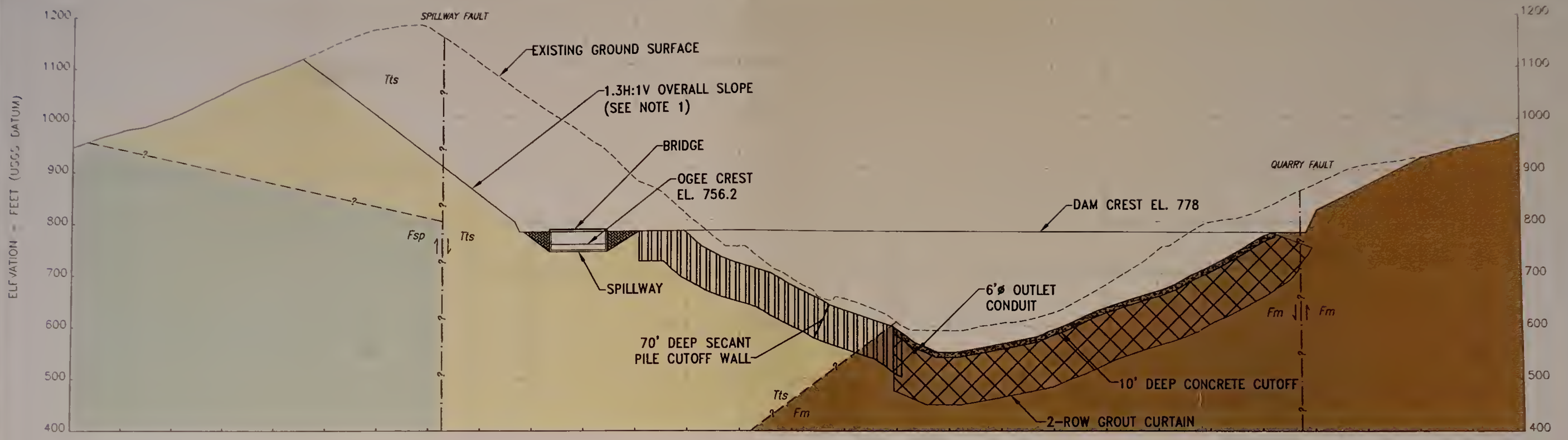
NOTE:

1. 1H:1V SLOPE BETWEEN 15'-WIDE

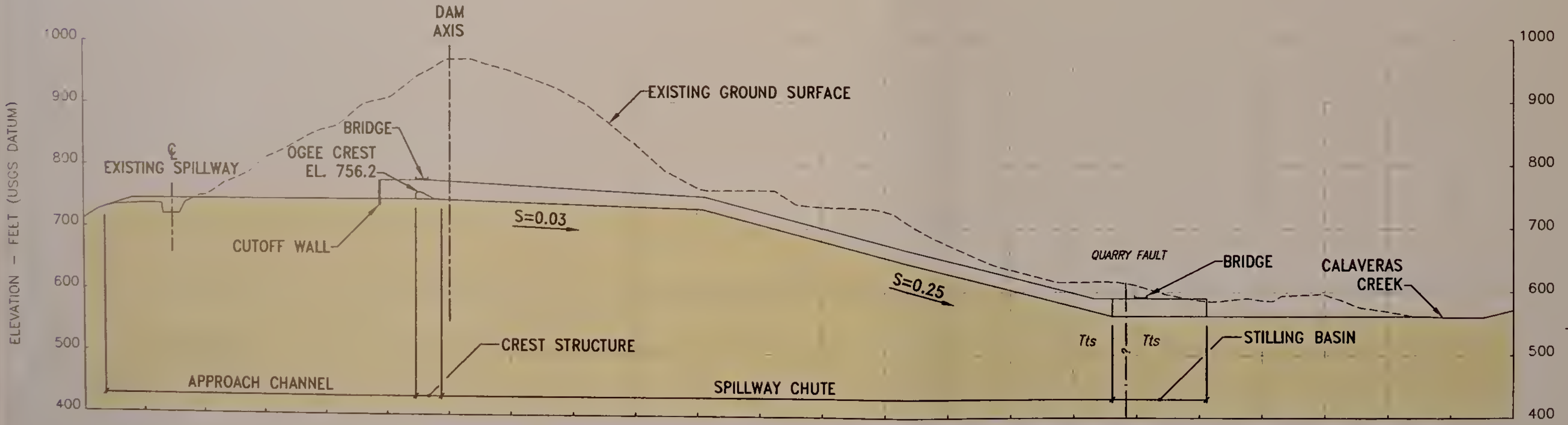
Oct 21, 2005 – 1:49pm
J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-2, 7-3, 7-5.dwg

EMBANKMENT DAM AND
SPILLWAY PROFILES

FIGURE
7–5


1200
1100
1000
900
800
700
600
500
400
ELEVATION – FEET (USGS DATUM)
SPILLWAY FAULT
EXISTING GROUND SURFACE
Tts
1.3H:1V OVERALL SLOPE (SEE NOTE 1)
BRIDGE
OGEE CREST EL. 756.2
Fsp
Tts
SPILLWAY
DAM CREST EL. 778
QUARRY FAULT
6'ø OUTLET CONDUIT
Fm
Fm
70' DEEP SECANT PILE CUTOFF WALL
10' DEEP CONCRETE CUTOFF
Tts
Fm
2-ROW GROUT CURTAIN
1200
1100
1000
900
800
700
600
500
400

SECTION $\frac{C}{7-3}$ – EMBANKMENT DAM PROFILE


1000
900
800
700
600
500
400
ELEVATION – FEET (USGS DATUM)
DAM AXIS
EXISTING GROUND SURFACE
BRIDGE
℄ EXISTING SPILLWAY
OGEE CREST EL. 756.2
S=0.03
CUTOFF WALL
S=0.25
QUARRY FAULT
BRIDGE
CALAVERAS CREEK
Tts
Tts
STILLING BASIN
CREST STRUCTURE
APPROACH CHANNEL
SPILLWAY CHUTE
1000
900
800
700
600
500
400

SECTION $\frac{D}{7-3}$ – SPILLWAY PROFILE

GEOLOGIC LEGEND

TERTIARY

Tts	TEMBLOR SANDSTONE

JURASSIC – CRETACEOUS

Fm	MELANGE/UNDIFFERENTIATED
Fsp	SERPENTINITE
—?—	GEOLOGIC CONTACT (APPROXIMATE)

NOTE:

1. 1H:1V SLOPE BETWEEN 15'-WIDE BENCHES AT 50' INTERVALS.

100' 0' 100' 200'
SCALE: 1"=200'

URS

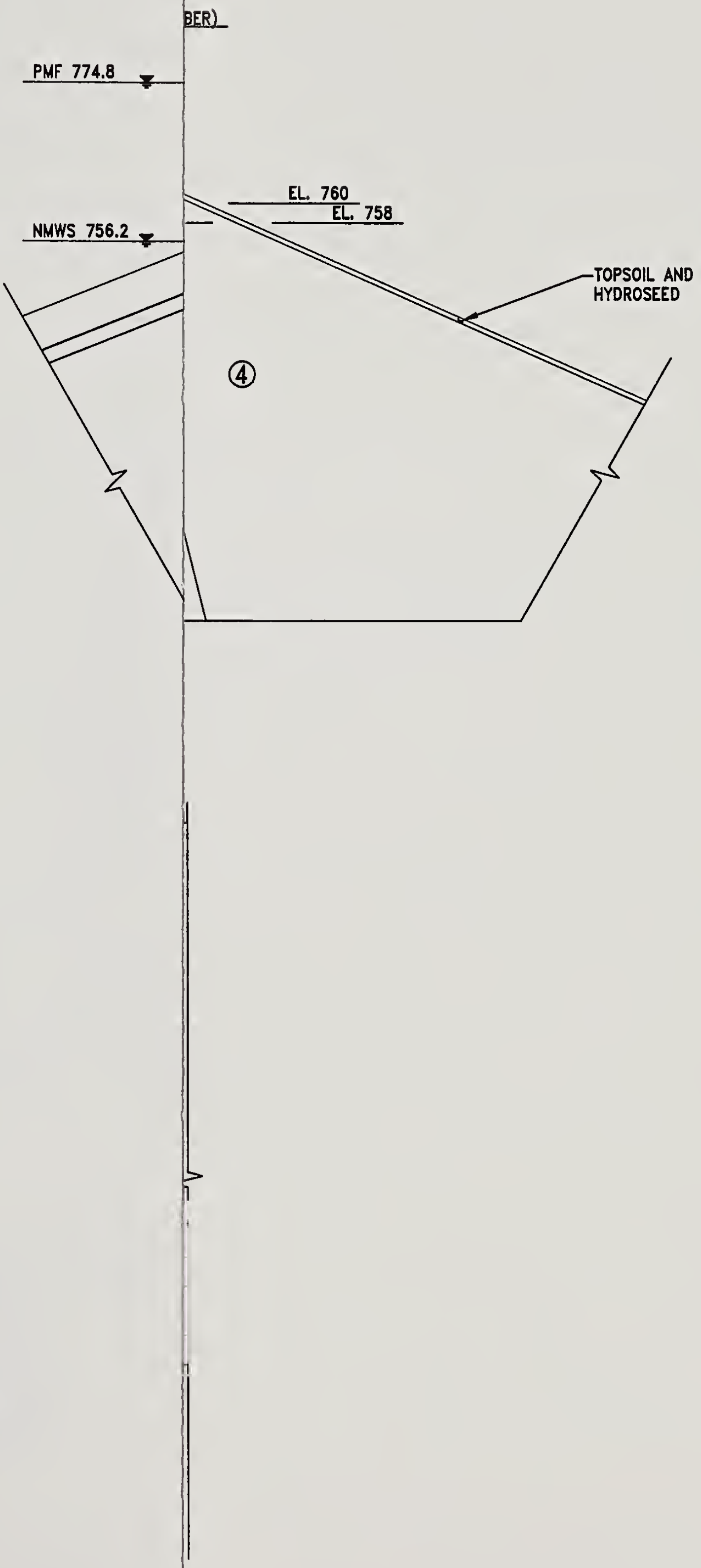
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

EMBANKMENT DAM AND SPILLWAY PROFILES

FIGURE 7-5

Oct 21, 2005 – 1:49pm
J:\CADSHAR(D)\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-2, 7-3, 7-5.dwg


BER)
PMF 774.8
EL. 760
EL. 758
NMWS 756.2
TOPSOIL AND HYDROSEED
④

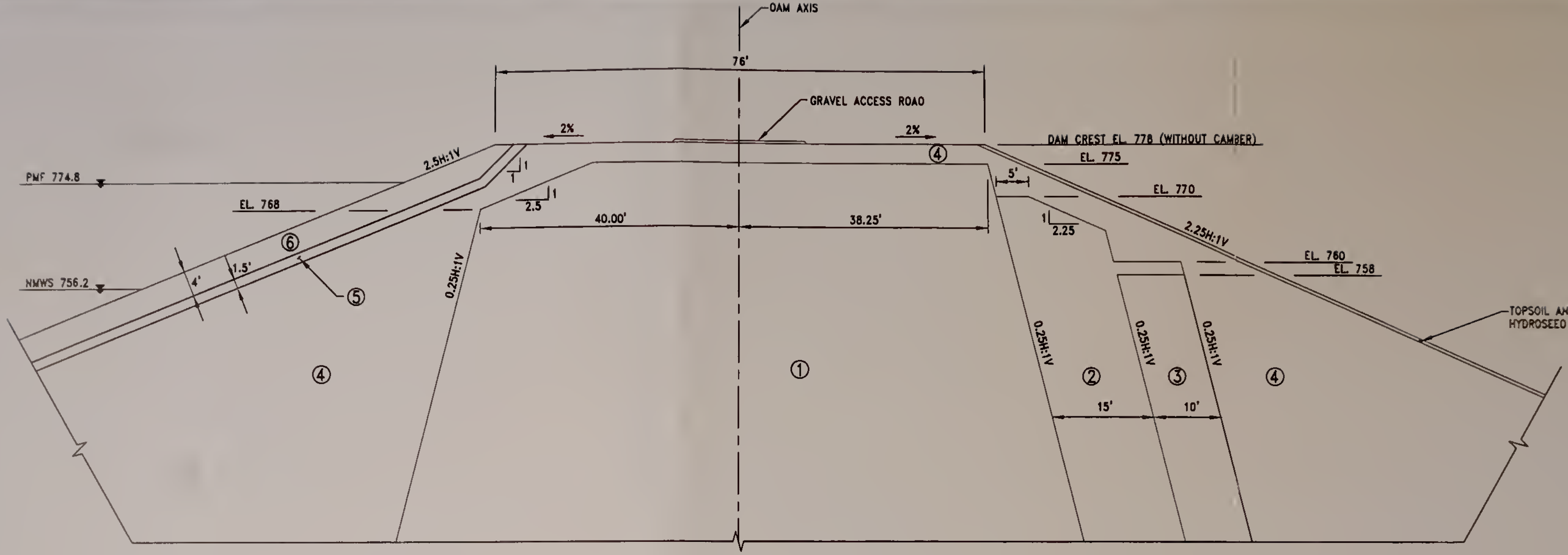
LEGEND

① CORE
② FILTER
③ DRAIN
④ SHELL
⑤ BEDDING
⑥ RIPRAP

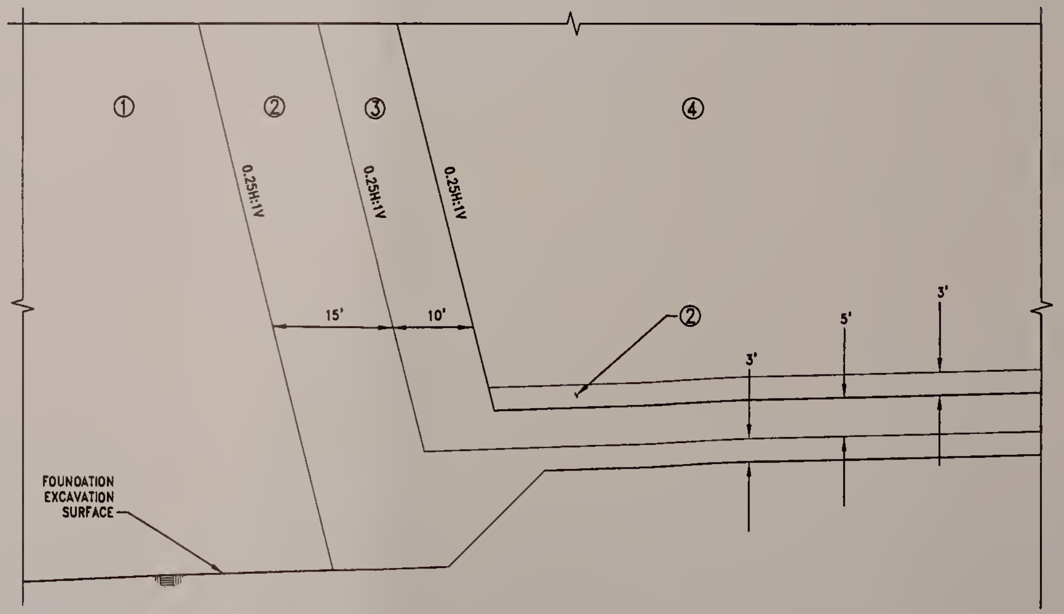
EMBANKMENT DAM DETAILS

FIGURE 7–6

J:\CADSHARED\Calaveras Dam\DAMS–SPILLWAYS–5–20–04\dwg\CER\7–6.dwg, 7–6


DAM AXIS
76'
GRAVEL ACCESS ROAD
2%
2%
DAM CREST EL. 778 (WITHOUT CAMBER)
EL. 775
EL. 770
2.5H:1V
PMF 774.8
EL. 768
1
1
1
2.5
40.00'
38.25'
5'
1
2.25
2.25H:1V
EL. 760
EL. 758
NMWS 756.2
4'
1.5'
⑥
⑤
④
0.25H:1V
①
0.25H:1V
0.25H:1V
0.25H:1V
②
③
④
15'
10'
TOPSOIL AND HYDROSEED

CREST DETAIL


①
②
③
④
0.25H:1V
0.25H:1V
0.25H:1V
15'
10'
②
3'
5'
3'
FOUNDATION EXCAVATION SURFACE

DOWNSTREAM TOE OF CORE DETAIL

LEGEND

① CORE
② FILTER
③ DRAIN
④ SHELL
⑤ BEDDING
⑥ RIPRAP

10' 0 10' 20'
SCALE: 1"=20'

URS

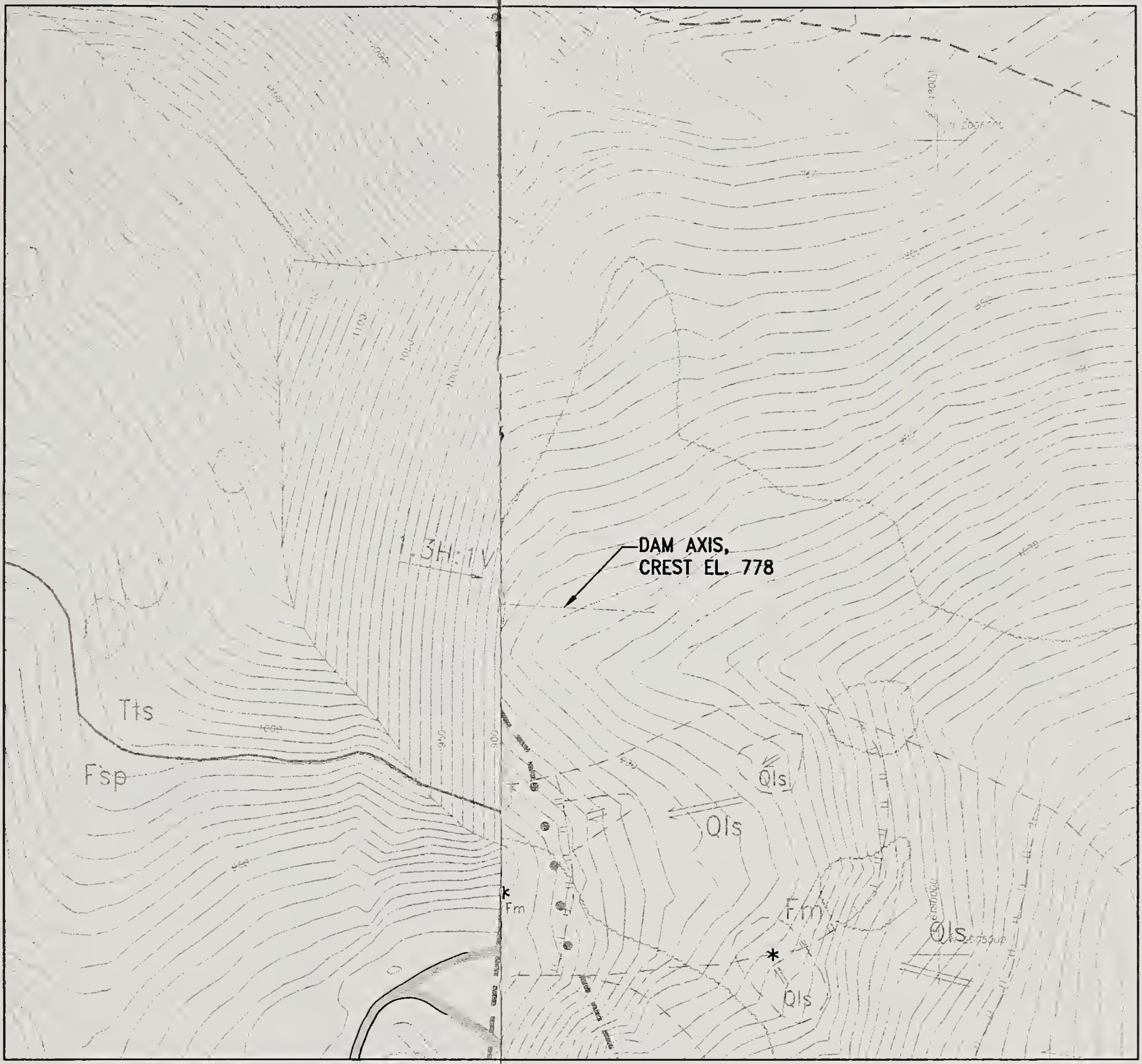
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

EMBANKMENT DAM DETAILS

FIGURE
7-6

\\ADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CTR\7-6.dwg, 7-6


DAM AXIS,
CREST EL. 778
1.3H:1V
Tts
Fsp
Qls
Qls
Qls
Qls
Fm
Fm

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-7.dwg, 7-7

LEGEND OF EMBANKMENT DAM ZONES

① CORE
② FILTER
③ DRAIN
④ SHELL
⑤ BEDDING
⑥ RIPRAP

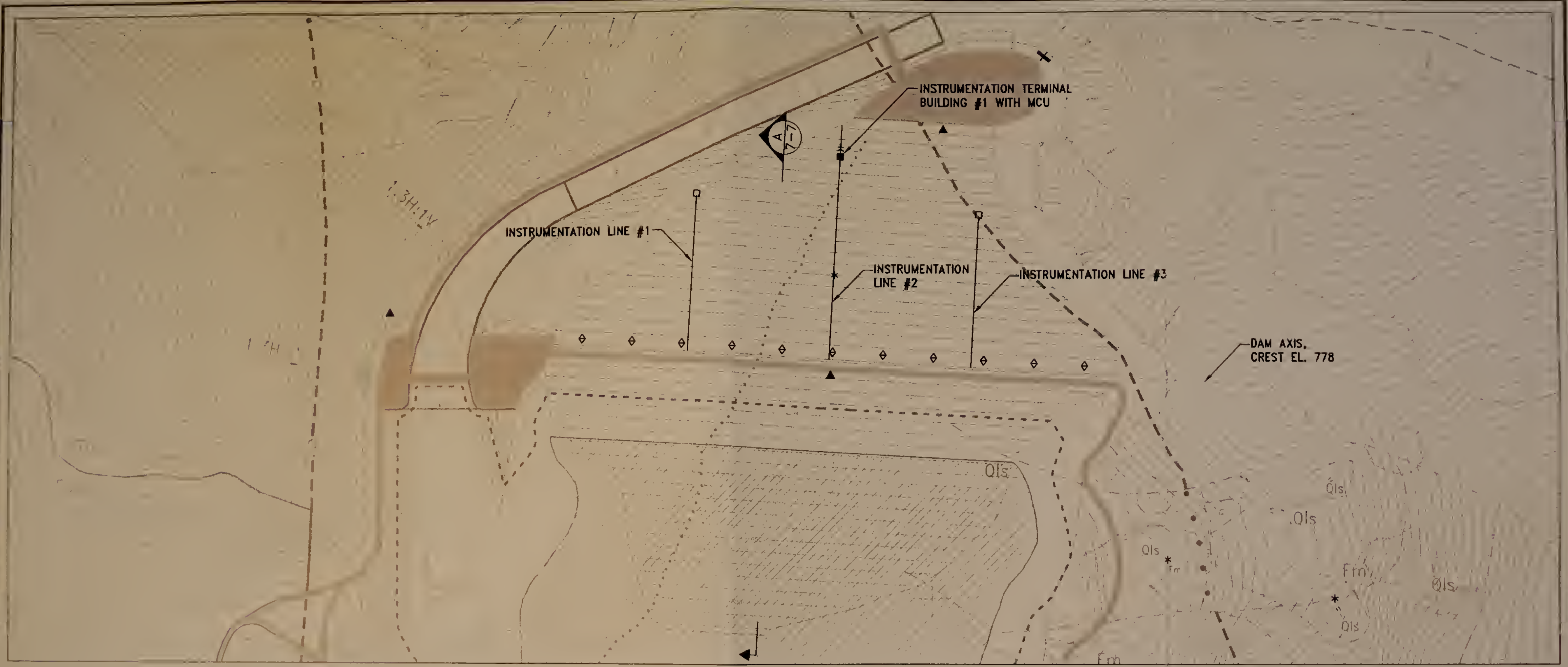
ITATION LEGEND

IETER (OPEN STANDPIPE)
IETER (VIBRATING WIRE)
ROGRAPH
)METER
Y MONUMENT

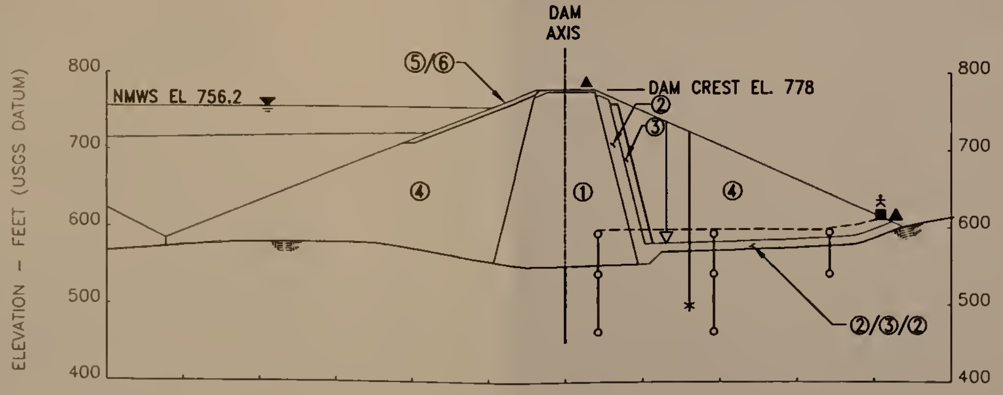
MENT TERMINAL BUILDING
MENT TERMINAL VAULT
GE MEASUREMENT V-NOTCH WEIR
MENTATION TRENCH
MENTATION LINE

INSTRUMENTATION PLAN

FIGURE
7-7


INSTRUMENTATION TERMINAL BUILDING #1 WITH MCU
A 7-7
1.3H:1V
INSTRUMENTATION LINE #1
INSTRUMENTATION LINE #2
INSTRUMENTATION LINE #3
DAM AXIS, CREST EL. 778
Qls
Qls
Qls
Qls
Qls
Qls
Fm
Fm
Fm

LEGEND OF EMBANKMENT DAM ZONES
① CORE
② FILTER
③ DRAIN
④ SHELL
⑤ BEDDING
⑥ RIPRAP


DAM AXIS
800
700
600
500
400
800
700
600
500
400
ELEVATION - FEET (USGS DATUM)
NMWS EL 756.2
⑤/⑥
DAM CREST EL. 778
②
③
④
①
④
②/③/②

SECTION A/7-7 - INSTRUMENTATION AT MAXIMUM DAM SECTION

INSTRUMENTATION LEGEND

▽	PIEZOMETER (OPEN STANDPIPE)
○	PIEZOMETER (VIBRATING WIRE)
▲	ACCELEROGRAPH
*	INCLINOMETER
◇	SURVEY MONUMENT
⚲	MCU
■	INSTRUMENT TERMINAL BUILDING
□	INSTRUMENT TERMINAL VAULT
+	SEEPAGE MEASUREMENT V-NOTCH WEIR
---	INSTRUMENTATION TRENCH
—	INSTRUMENTATION LINE

100' 0' 100' 200'
SCALE: 1"=200'

URS

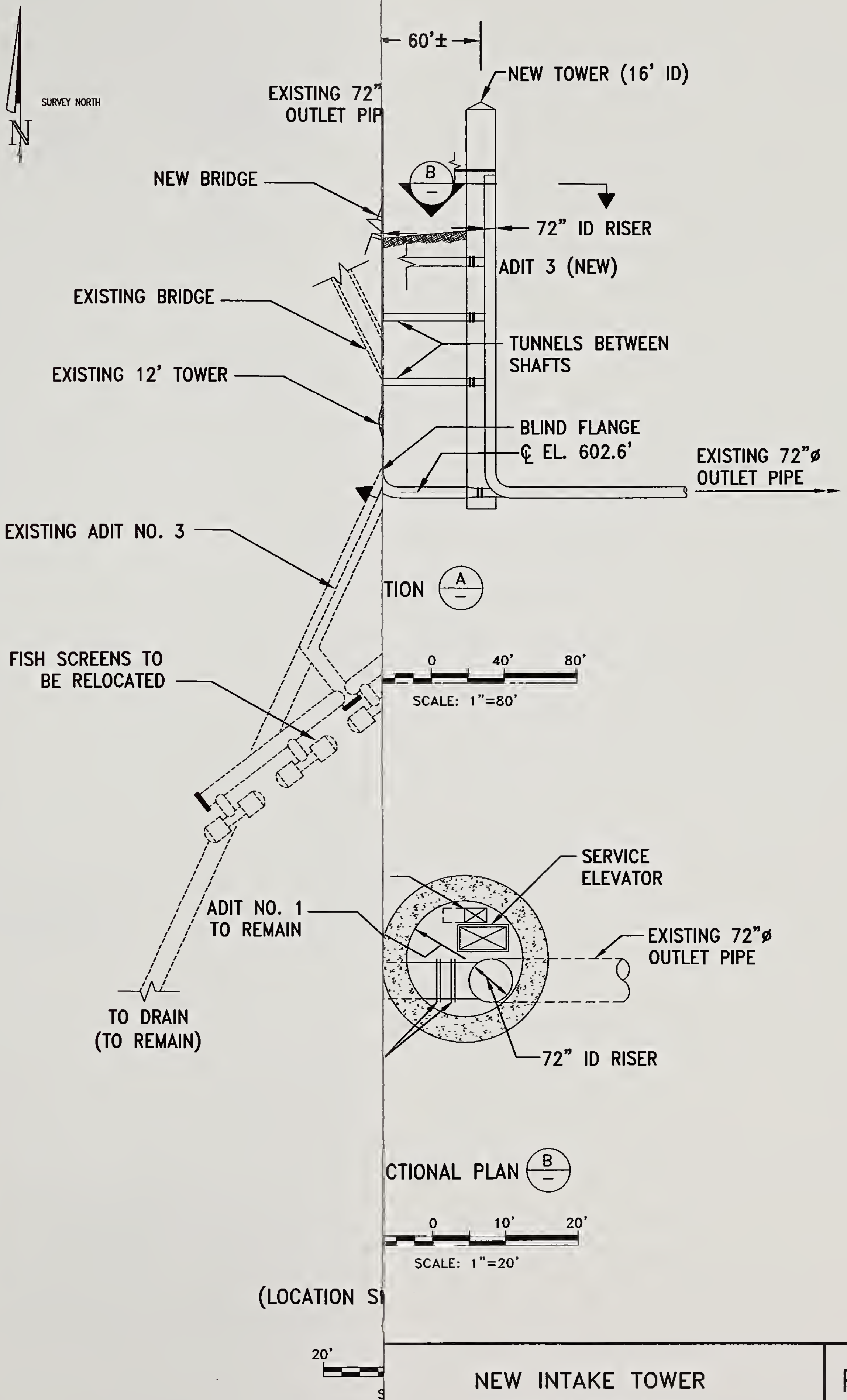
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

INSTRUMENTATION PLAN

FIGURE
7-7

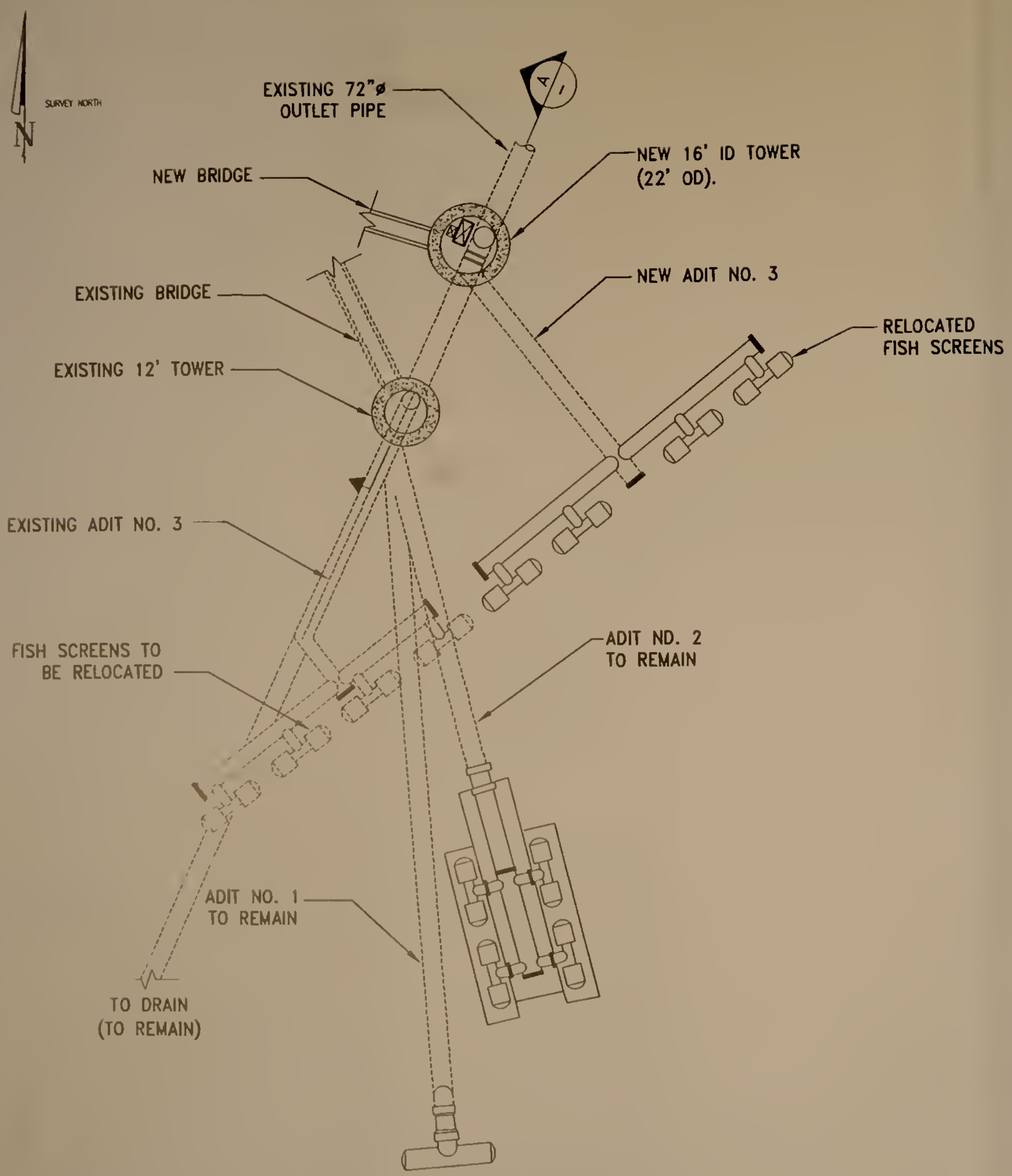
J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CERI7-7.dwg, 7-7


SURVEY NORTH
N
EXISTING 72"
OUTLET PIP
NEW BRIDGE
EXISTING BRIDGE
EXISTING 12' TOWER
EXISTING ADIT NO. 3
FISH SCREENS TO BE RELOCATED
ADIT NO. 1 TO REMAIN
TO DRAIN (TO REMAIN)
60'±
NEW TOWER (16' ID)
B
72" ID RISER
ADIT 3 (NEW)
TUNNELS BETWEEN SHAFTS
BLIND FLANGE
℄ EL. 602.6'
EXISTING 72"ø OUTLET PIPE
TION A
0 40' 80'
SCALE: 1"=80'
SERVICE ELEVATOR
EXISTING 72"ø OUTLET PIPE
72" ID RISER
CTIONAL PLAN B
0 10' 20'
SCALE: 1"=20'
(LOCATION S
20'

NEW INTAKE TOWER
PLAN & SECTIONS

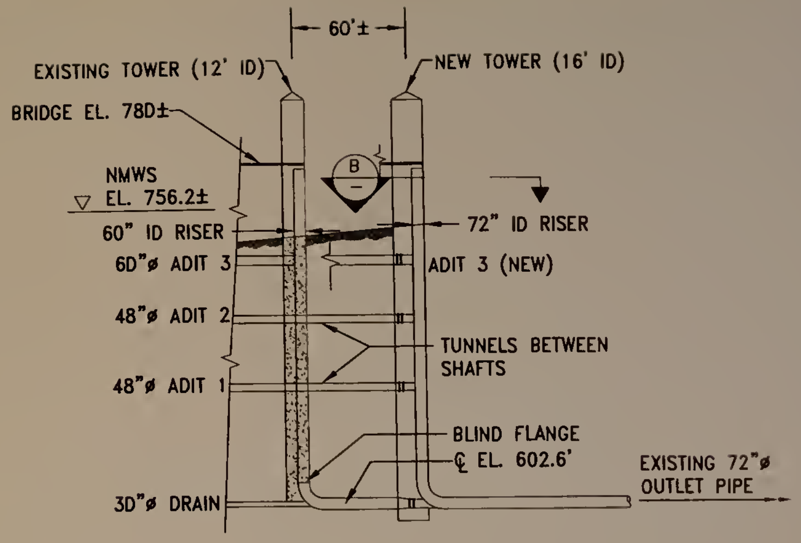
FIGURE
7–8

Oct 21, 2005 – 1:39pm
J:\CADSHARED\Calaveras Dam\DAMS–SPILLWAYS–5–20–04\dwg\CER\7–8.dwg


SURVEY NORTH
N
EXISTING 72"ø OUTLET PIPE
A
NEW BRIDGE
NEW 16' ID TOWER (22' OD).
EXISTING BRIDGE
NEW ADIT NO. 3
EXISTING 12' TOWER
RELOCATED FISH SCREENS
EXISTING ADIT NO. 3
FISH SCREENS TO BE RELOCATED
ADIT NO. 2 TO REMAIN
ADIT NO. 1 TO REMAIN
TO DRAIN (TO REMAIN)

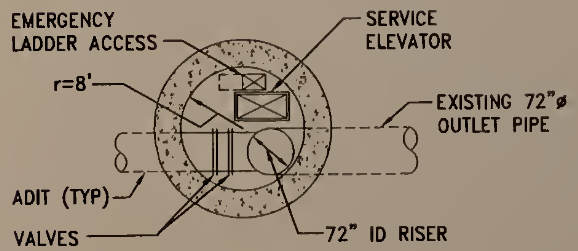
PLAN
(LOCATION SHOWN ON FIGURE 7-3)

20' 0 20' 40'
SCALE: 1"=40'


60'±
EXISTING TOWER (12' ID)
NEW TOWER (16' ID)
BRIDGE EL. 780±
B
NMWS EL. 756.2±
60" ID RISER
72" ID RISER
60"ø ADIT 3
ADIT 3 (NEW)
48"ø ADIT 2
TUNNELS BETWEEN SHAFTS
48"ø ADIT 1
BLIND FLANGE
℄ EL. 602.6'
EXISTING 72"ø OUTLET PIPE
30"ø DRAIN

SECTION (A)

40' 0 40' 80'
SCALE: 1"=80'

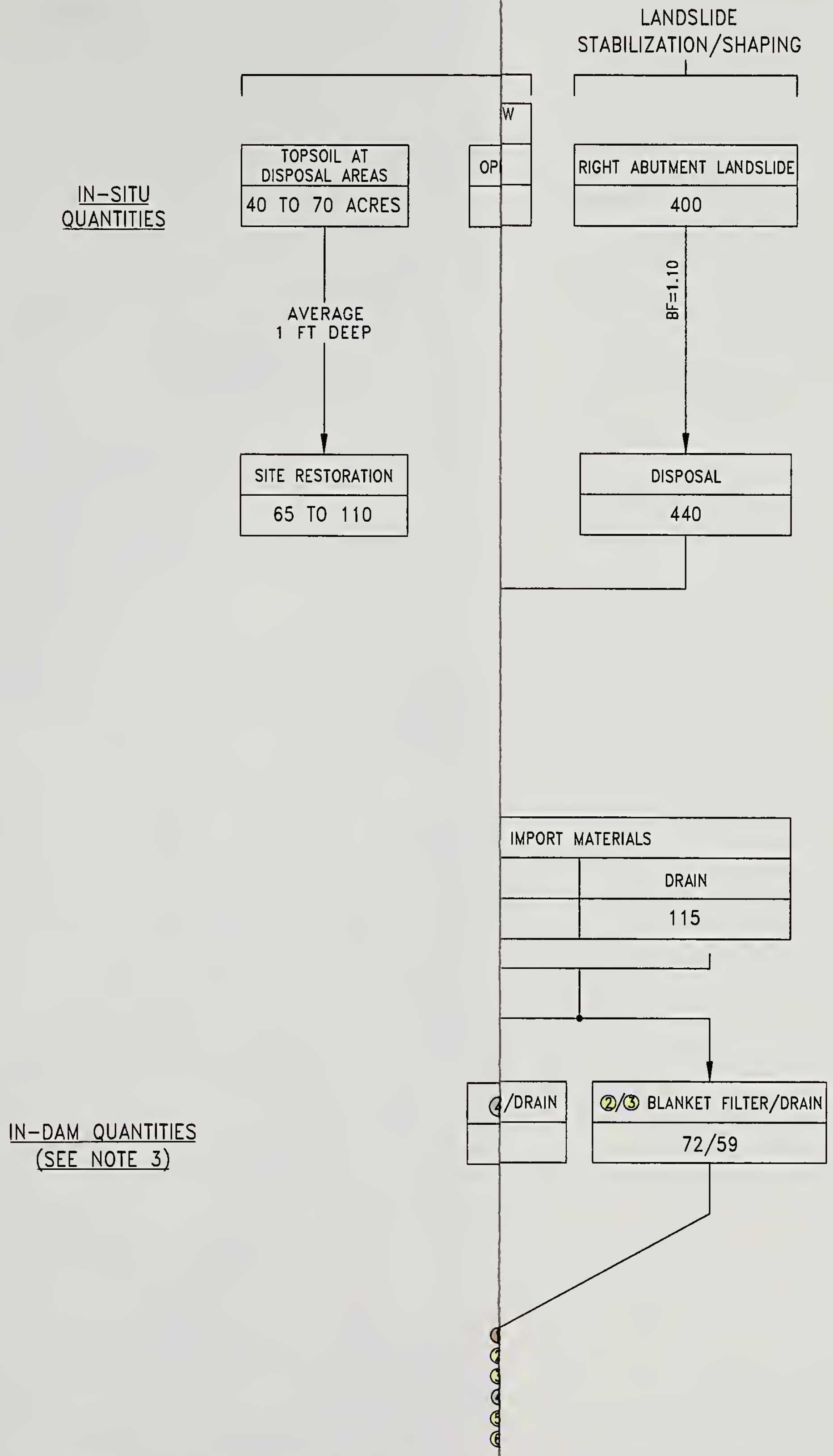

EMERGENCY LADDER ACCESS
SERVICE ELEVATOR
r=8'
EXISTING 72"ø OUTLET PIPE
ADIT (TYP)
VALVES
72" ID RISER

SECTIONAL PLAN (B)

10' 0 10' 20'
SCALE: 1"=20'

Oct 21, 2005 – 1:39pm
J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-8.dwg

URS	Project No. 26814817 SFPUC CALAVERAS DAM Agreement No. CS-716	NEW INTAKE TOWER PLAN & SECTIONS	FIGURE 7-8


LANDSLIDE STABILIZATION/SHAPING
IN-SITU QUANTITIES
TOPSOIL AT DISPOSAL AREAS
40 TO 70 ACRES
W
OP
RIGHT ABUTMENT LANDSLIDE
400
AVERAGE 1 FT DEEP
BF=1.10
SITE RESTORATION
65 TO 110
DISPOSAL
440
IMPORT MATERIALS
DRAIN
115
/DRAIN
②/③ BLANKET FILTER/DRAIN
72/59
IN-DAM QUANTITIES
(SEE NOTE 3)

NOTES:
1. QUANTITIES ARE IN THOUSANDS OF CUBIC YARDS
2. ALL EMBANKMENT QUANTITIES BASED ON DESIGN LINES
3. OVERBUILD ALLOWANCE NOT INCLUDED
4. DISPOSAL QUANTITY FROM SPILLWAY EXCAVATION WILL BE DEPENDENT ON RESERVE USED IN DAM.

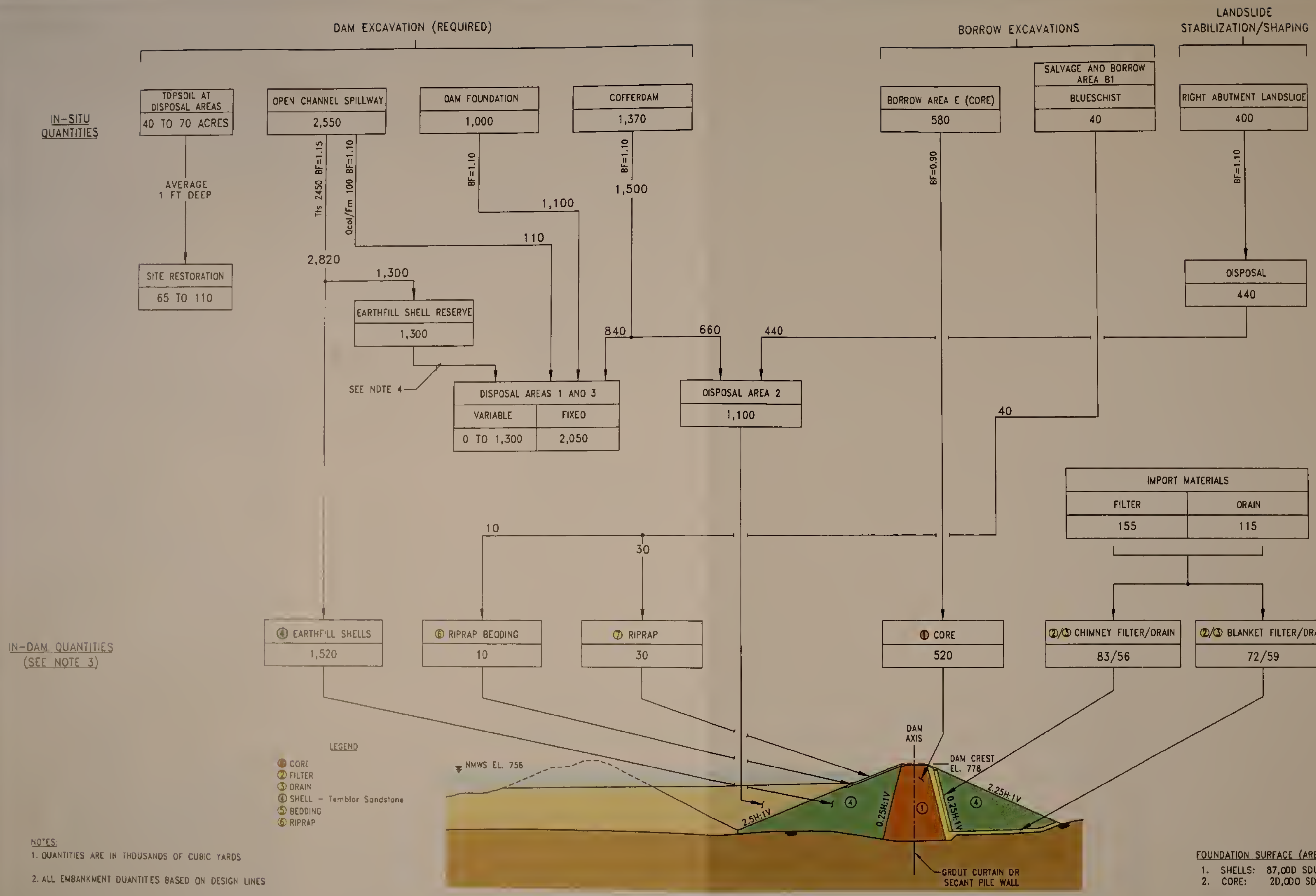
FOUNDATION SURFACE (AREA)
1. SHELLS: 87,000 SQUARE YARDS
2. CORE: 20,000 SQUARE YARDS

FOUNDATION CUTOFF (AREA)
1. SECANT PILE/DIAPHRAGM WALL: 41,000 SQUARE FEET (580' x 70')
2. 2-ROW GROUT CURTAIN: 70,000 SQUARE FEET (700' x 100')

MATERIAL BALANCE DIAGRAM

FIGURE
7-9

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-9.dwg, 7-9


DAM EXCAVATION (REQUIRED)
BORROW EXCAVATIONS
LANDSLIDE STABILIZATION/SHAPING
IN-SITU QUANTITIES
TOPSOIL AT DISPOSAL AREAS
40 TO 70 ACRES
OPEN CHANNEL SPILLWAY
2,550
DAM FOUNDATION
1,000
COFFERDAM
1,370
BORROW AREA E (CORE)
580
SALVAGE AND BORROW AREA B1
BLUESCHIST
40
RIGHT ABUTMENT LANDSLIDE
400
AVERAGE 1 FT DEEP
Tts 2450 BF=1.15
Qcol/Fm 100 BF=1.10
BF=1.10
BF=1.10
BF=0.90
BF=1.10
1,500
1,100
110
2,820
1,300
SITE RESTORATION
65 TO 110
EARTHFILL SHELL RESERVE
1,300
SEE NOTE 4
DISPOSAL AREAS 1 AND 3
VARIABLE
FIXED
0 TO 1,300
2,050
840
660
440
DISPOSAL AREA 2
1,100
DISPOSAL
440
40
IMPORT MATERIALS
FILTER
DRAIN
155
115
10
30
IN-DAM QUANTITIES (SEE NOTE 3)
④ EARTHFILL SHELLS
1,520
⑥ RIPRAP BEDDING
10
⑦ RIPRAP
30
① CORE
520
②/③ CHIMNEY FILTER/DRAIN
83/56
②/③ BLANKET FILTER/DRAIN
72/59
LEGEND
① CORE
② FILTER
③ DRAIN
④ SHELL - Temblor Sandstone
⑤ BEDDING
⑥ RIPRAP
NMWS EL. 756
DAM AXIS
DAM CREST EL. 778
2.5H:1V
0.25H:1V
0.25H:1V
2.25H:1V
④
①
④
GROUT CURTAIN OR SECANT PILE WALL

NOTES:

1. QUANTITIES ARE IN THOUSANDS OF CUBIC YARDS
2. ALL EMBANKMENT QUANTITIES BASED ON DESIGN LINES
3. OVERBUILD ALLOWANCE NOT INCLUDED
4. DISPOSAL QUANTITY FROM SPILLWAY EXCAVATION WILL BE DEPENDENT ON RESERVE USED IN DAM.

FOUNDATION SURFACE (AREA)

1. SHELLS: 87,000 SQUARE YARDS
2. CORE: 20,000 SQUARE YARDS

FOUNDATION CUTOFF (AREA)

1. SECANT PILE/DIAPHRAGM WALL: 41,000 SQUARE FEET (580' x 70')
2. 2-ROW GROUT CURTAIN: 70,000 SQUARE FEET (700' x 100')

URS

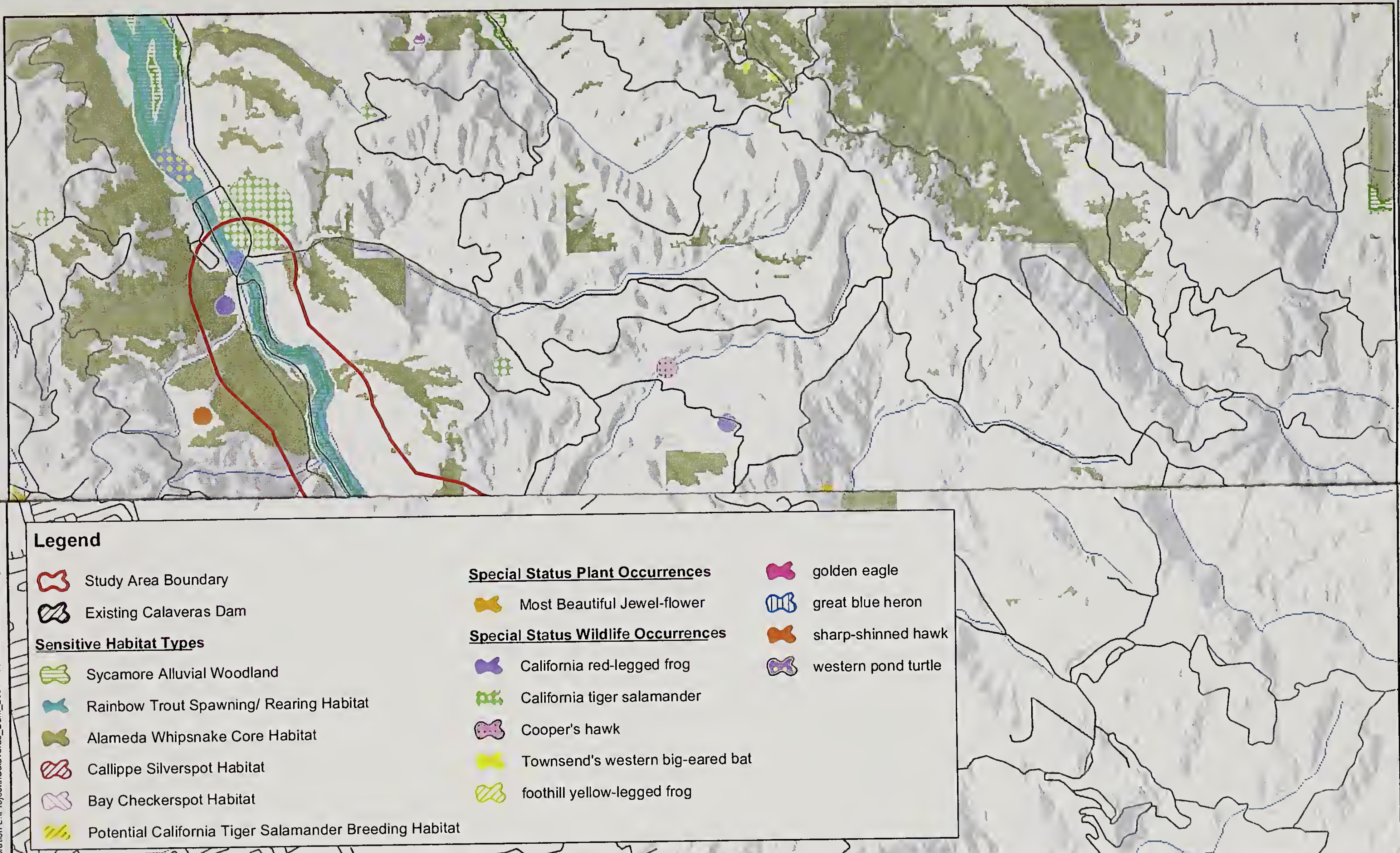
Project No. 26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

MATERIAL BALANCE DIAGRAM

FIGURE
7-9

J:\CADSHARED\Calaveras Dam\DAMS-SPILLWAYS-5-20-04\dwg\CER\7-9.dwg, 7-9


Legend
Study Area Boundary
Existing Calaveras Dam
Sensitive Habitat Types
Sycamore Alluvial Woodland
Rainbow Trout Spawning/ Rearing Habitat
Alameda Whipsnake Core Habitat
Callippe Silverspot Habitat
Bay Checkerspot Habitat
Potential California Tiger Salamander Breeding Habitat
Special Status Plant Occurrences
Most Beautiful Jewel-flower
Special Status Wildlife Occurrences
California red-legged frog
California tiger salamander
Cooper's hawk
Townsend's western big-eared bat
foothill yellow-legged frog
golden eagle
great blue heron
sharp-shinned hawk
western pond turtle
N
1
0.5
0
1
Miles

Sources: Callippe silverspot and bay checkerspot habitat mapping provided by Dr. Richard Arnold (2004). Sycamore alluvial woodland mapping is based on California Natural Diversity Data Base (CNDDB 2004) and Alameda Watershed vegetation mapping provided by SFPUC (2004). ; Alameda whipsnake core habitat is based on Alameda Watershed vegetation mapping of referenced vegetation types based on a similar map compiled by Karen Swaim for SFPUC; proposed critical habitat for Central California Coast Steelhead ESU is based on CNDDB and information published in the June 14, 2004 Federal Register critical habitat proposal (vol. 69, no. 113); habitats that may be suitable for California tiger salamander breeding are identified based on the natural pond, quarry pond, and stock pond communities identified in the Alameda Watershed vegetation mapping; special status species occurrence mapping is from the CNDDB (2004).

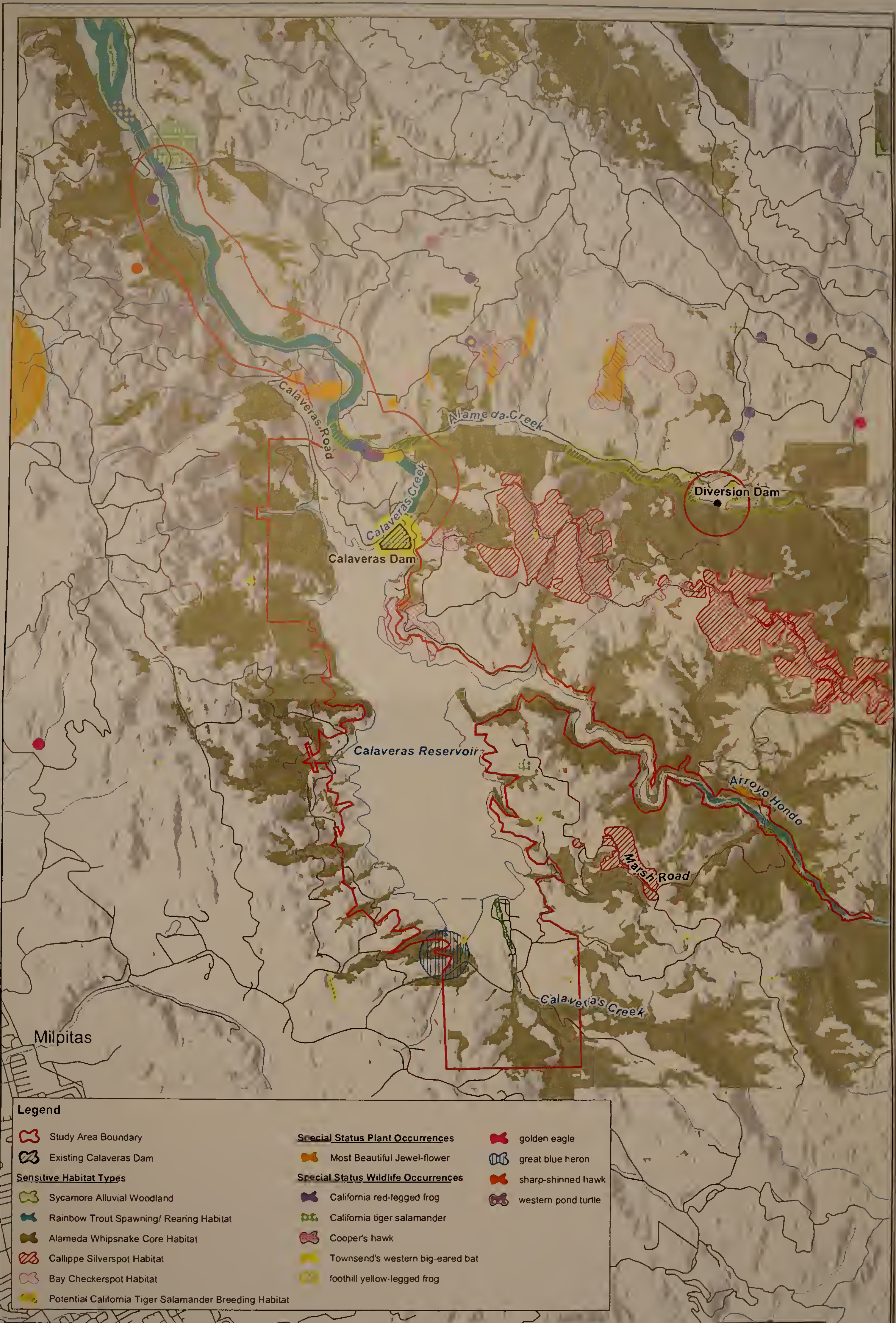
URS Corporation L:\Projects\Calaveras_Dam_26814408\Mxd\Current Working Documents\TM

URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Special Status Species Habitats and Known Occurrences in the Study Area

Figure 8-1


Diversion Dam
Alameda Creek
Calaveras Road
Calaveras Creek
Calaveras Dam
Calaveras Reservoir
Arroyo Hondo
Marsh Road
Calaveras Creek
Milpitas
Legend
Study Area Boundary
Existing Calaveras Dam
Sensitive Habitat Types
Sycamore Alluvial Woodland
Rainbow Trout Spawning/ Rearing Habitat
Alameda Whipsnake Core Habitat
Callippe Silverspot Habitat
Bay Checkerspot Habitat
Potential California Tiger Salamander Breeding Habitat
Special Status Plant Occurrences
Most Beautiful Jewel-flower
Special Status Wildlife Occurrences
California red-legged frog
California tiger salamander
Cooper's hawk
Townsend's western big-eared bat
foothill yellow-legged frog
golden eagle
great blue heron
sharp-shinned hawk
western pond turtle

Sources Callippe silverspot and bay checkerspot habitat mapping provided by Dr. Richard Arnold (2004). Sycamore alluvial woodland mapping is based on California Natural Diversity Data Base (CNDDB 2004) and Alameda Watershed vegetation mapping provided by SFPUC (2004) , Alameda whipsnake core habitat is based on Alameda Watershed vegetation mapping of referenced vegetation types based on a similar map compiled by Karen Swaim for SFPUC, proposed critical habitat for Central California Coast Steelhead ESU is based on CNDDB and information published in the June 14, 2004 Federal Register critical habitat proposal (vol 69, no. 113); habitats that may be suitable for California tiger salamander breeding are identified based on the natural pond, quarry pond, and stock pond communities identified in the Alameda Watershed vegetation mapping; special status species occurrence mapping is from the CNDDB (2004).

N 1 0.5 0 1 Miles

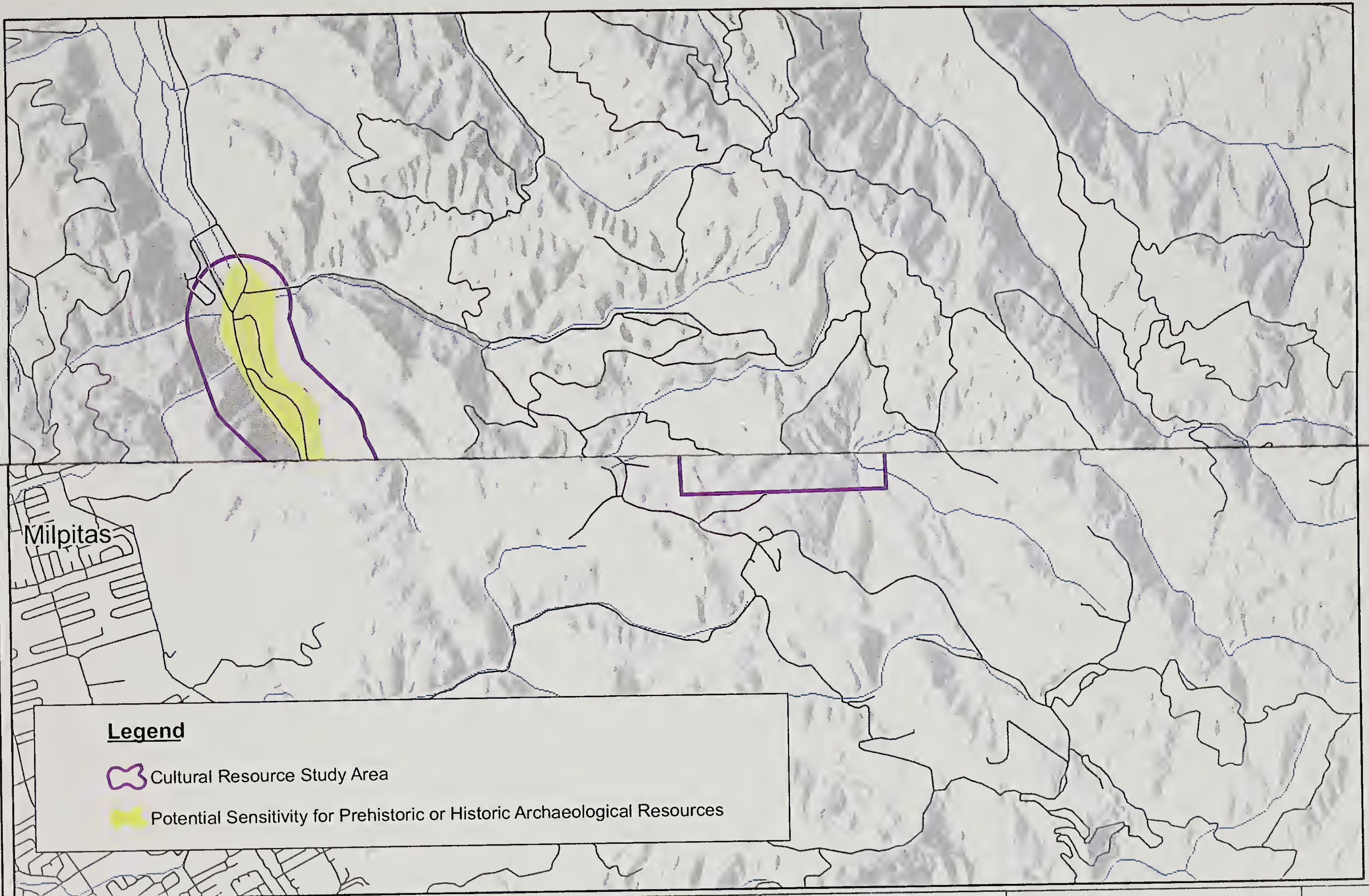
URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Special Status Species Habitats and Known Occurrences in the Study Area

Figure 8-1

URS Corporation L:\Projects\Calaveras_Dam_26814408\Mxd\Current Working Documents\TM_8_0\Figure_8-1_Special_Status_Species.mxd Date 3/23/2005 10:52:12 AM Name kvhoppe0


Milpitas
Legend
Cultural Resource Study Area
Potential Sensitivity for Prehistoric or Historic Archaeological Resources
N
1
0.5
0
1
Miles

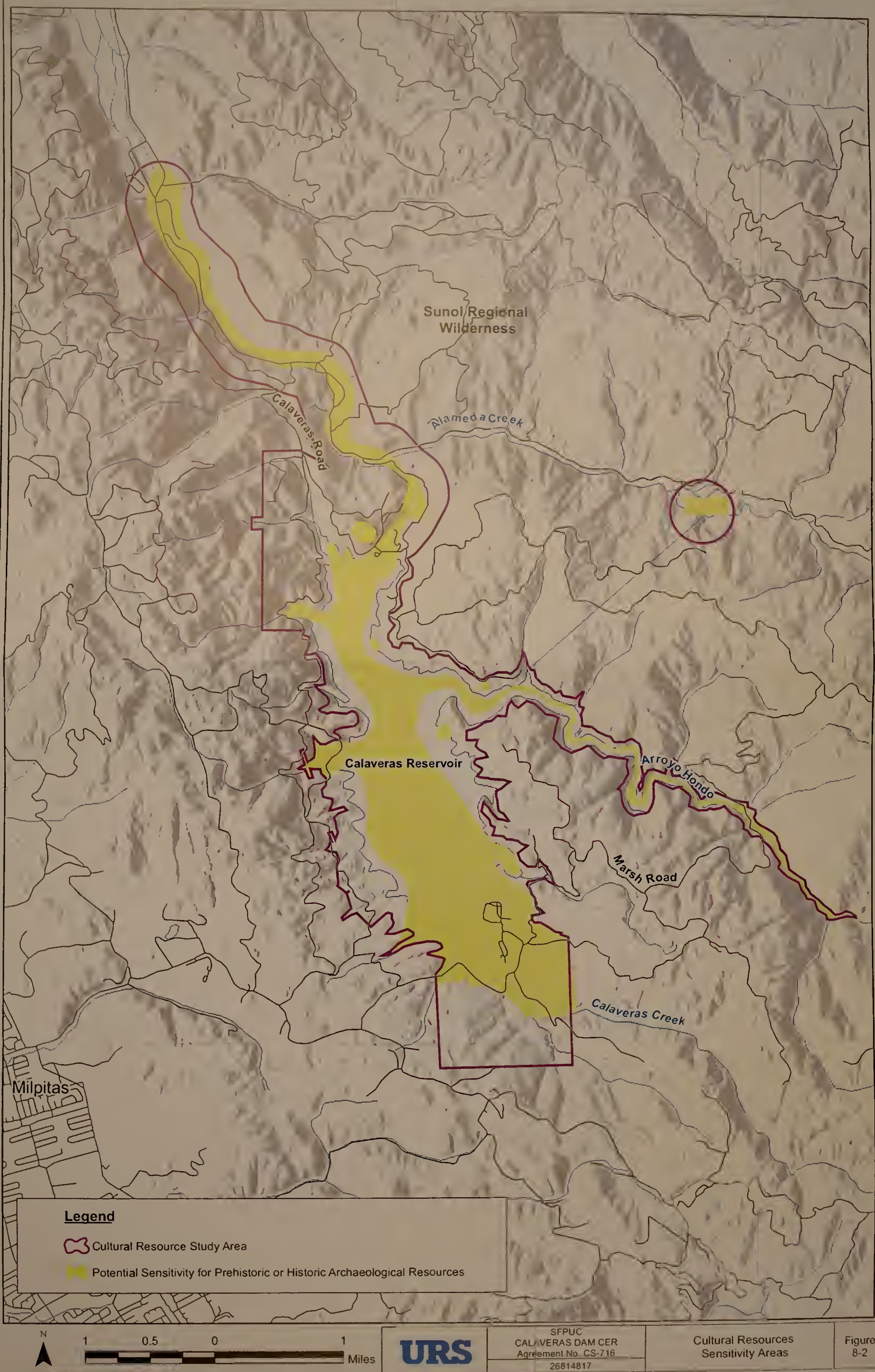
URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Cultural Resources
Sensitivity Areas

Figure
8-2

URS Corporation L:\Projects\Calaveras_Dam_26814408\Mxd\Current Working Documents


Sunol Regional Wilderness
Alameda Creek
Calaveras Road
Calaveras Reservoir
Arroyo Hondo
Marsh Road
Calaveras Creek
Milpitas
Legend
Cultural Resource Study Area
Potential Sensitivity for Prehistoric or Historic Archaeological Resources
N
1
0.5
0
1
Miles

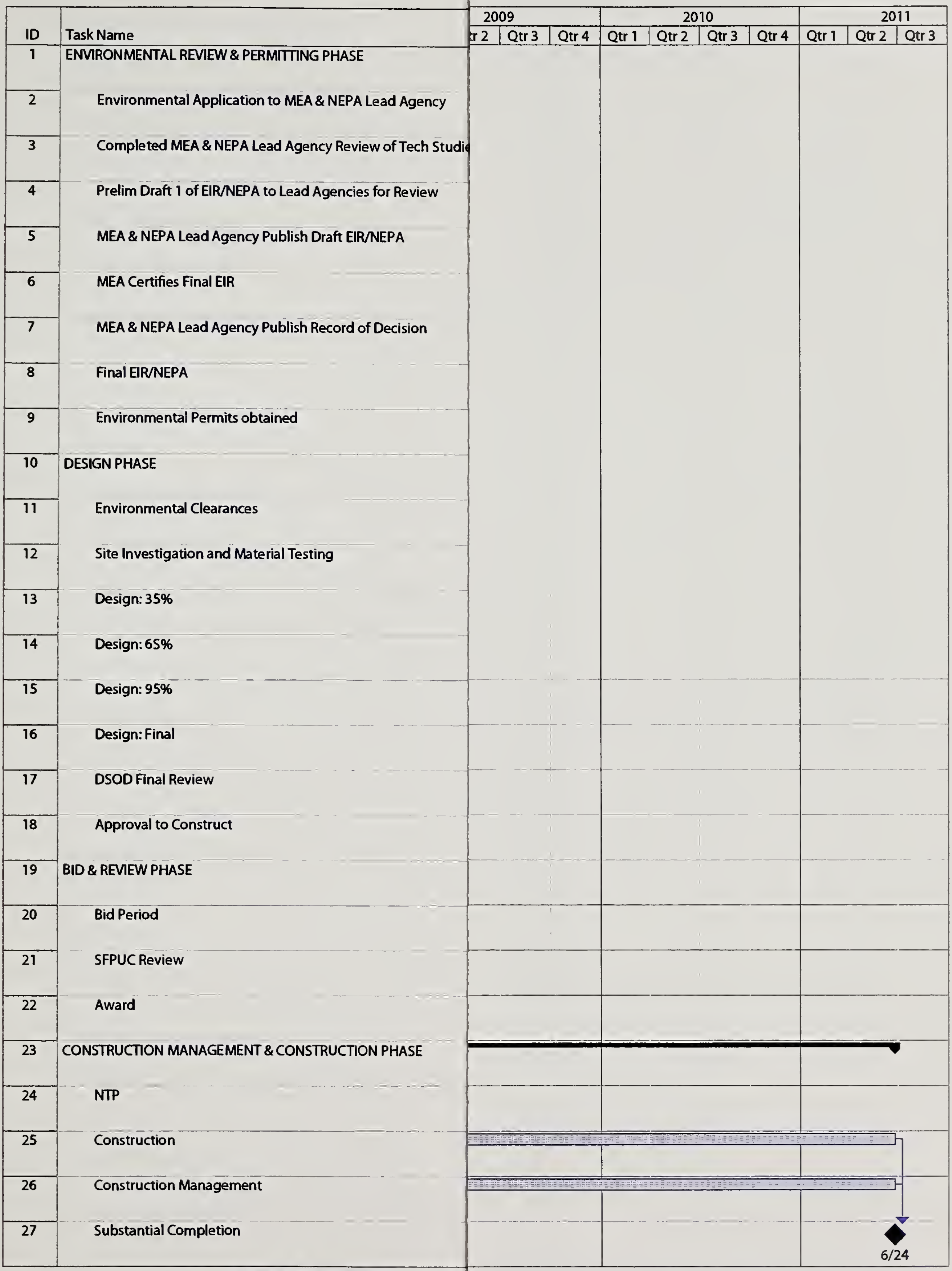
URS

SFPUC
CALAVERAS DAM CER
Agreement No. CS-716
26814817

Cultural Resources Sensitivity Areas

Figure 8-2

URS Corporation L:\Projects\Calaveras_Dam_26814406\Mxd\Current Working Documents TM_8_0\Figure_8-2_Cultural_Resources_sensitivity_areas.mxd Date: 3/23/2005 10:59:53 AM Name: kvhoppe0



ID	Task Name
1	ENVIRONMENTAL REVIEW & PERMITTING PHASE
2	Environmental Application to MEA & NEPA Lead Agency
3	Completed MEA & NEPA Lead Agency Review of Tech Studi
4	Prelim Draft 1 of EIR/NEPA to Lead Agencies for Review
5	MEA & NEPA Lead Agency Publish Draft EIR/NEPA
6	MEA Certifies Final EIR
7	MEA & NEPA Lead Agency Publish Record of Decision
8	Final EIR/NEPA
9	Environmental Permits obtained
10	DESIGN PHASE
11	Environmental Clearances
12	Site Investigation and Material Testing
13	Design: 35%
14	Design: 65%
15	Design: 95%
16	Design: Final
17	DSOD Final Review
18	Approval to Construct
19	BID & REVIEW PHASE
20	Bid Period
21	SFPUC Review
22	Award
23	CONSTRUCTION MANAGEMENT & CONSTRUCTION PHASE
24	NTP
25	Construction
26	Construction Management
27	Substantial Completion

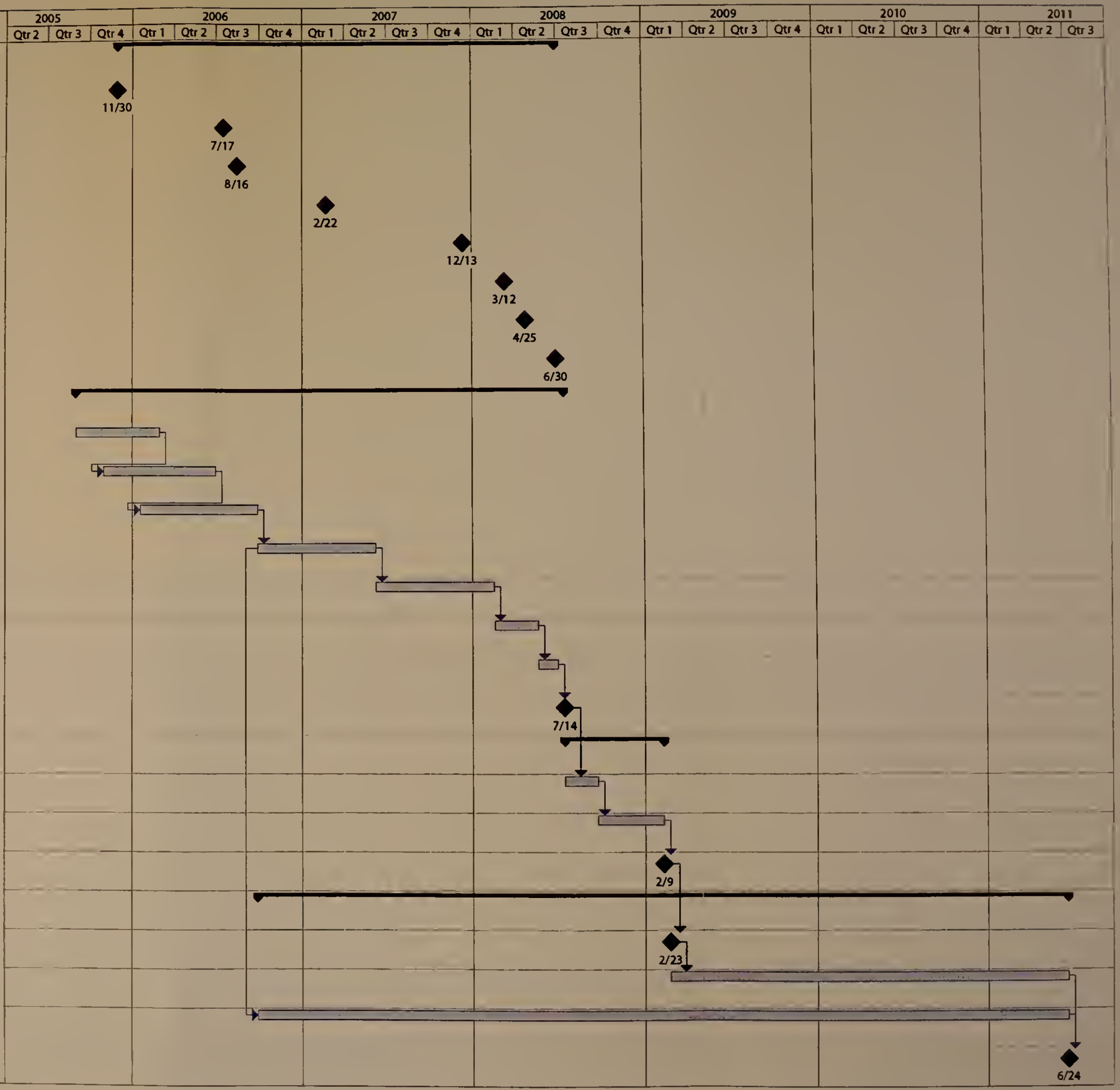
Task ▨ Milestone

REPLACEMENT PROJECT
TATION SCHEDULE

Figure
10-1

\x_geo\Calaveras CER\Task 14\Final CER Figures\Figure 10-1.ai

ID	Task Name	Duration	Start	Finish
1	ENVIRONMENTAL REVIEW & PERMITTING PHASE	134.6 wks	Wed 11/30/05	Mon 6/30/08
2	Environmental Application to MEA & NEPA Lead Agency	0 wks	Wed 11/30/05	Wed 11/30/05
3	Completed MEA & NEPA Lead Agency Review of Tech Studies	0 wks	Mon 7/17/06	Mon 7/17/06
4	Prelim Draft 1 of EIR/NEPA to Lead Agencies for Review	0 wks	Wed 8/16/06	Wed 8/16/06
5	MEA & NEPA Lead Agency Publish Draft EIR/NEPA	0 wks	Thu 2/22/07	Thu 2/22/07
6	MEA Certifies Final EIR	0 wks	Thu 12/13/07	Thu 12/13/07
7	MEA & NEPA Lead Agency Publish Record of Decision	0 wks	Wed 3/12/08	Wed 3/12/08
8	Final EIR/NEPA	0 wks	Fri 4/25/08	Fri 4/25/08
9	Environmental Permits obtained	0 wks	Mon 6/30/08	Mon 6/30/08
10	DESIGN PHASE	149.4 wks	Fri 9/2/05	Mon 7/14/08
11	Environmental Clearances	25.6 wks	Fri 9/2/05	Tue 2/28/06
12	Site Investigation and Material Testing	34.7 wks	Tue 11/1/05	Fri 6/30/06
13	Design: 35%	36.2 wks	Wed 1/18/06	Wed 9/27/06
14	Design: 65%	36.2 wks	Thu 9/28/06	Thu 6/7/07
15	Design: 95%	36.2 wks	Fri 6/8/07	Fri 2/15/08
16	Design: Final	13.2 wks	Mon 2/18/08	Mon 5/19/08
17	DSOD Final Review	6 wks	Tue 5/20/08	Mon 6/30/08
18	Approval to Construct	0 wks	Mon 7/14/08	Mon 7/14/08
19	BID & REVIEW PHASE	30 wks	Tue 7/15/08	Mon 2/9/09
20	Bid Period	10 wks	Tue 7/15/08	Mon 9/22/08
21	SFPUC Review	20 wks	Tue 9/23/08	Mon 2/9/09
22	Award	0 wks	Mon 2/9/09	Mon 2/9/09
23	CONSTRUCTION MANAGEMENT & CONSTRUCTION PHASE	247.4 wks	Thu 9/28/06	Fri 6/24/11
24	NTP	0 wks	Mon 2/23/09	Mon 2/23/09
25	Construction	121.8 wks	Tue 2/24/09	Fri 6/24/11
26	Construction Management	247.4 wks	Thu 9/28/06	Fri 6/24/11
27	Substantial Completion	0 wks	Fri 6/24/11	Fri 6/24/11



Task ▭ Milestone ◆ Summary ▬

URS

26814817

Calaveras Dam Replacement Project

CALAVERAS DAM REPLACEMENT PROJECT IMPLEMENTATION SCHEDULE

Figure 10-1

x geo Calaveras CER\Task 14\Final CER Figures\Figure 10-1.ai

Appendix A

Transition Memorandum: Development of Calaveras Dam Replacement Project (01CUW37401-A)

URS

Memorandum

Date: April 21, 2005

To: Chris Nelson, Senior Project Manager, SFPUC

From: Noel Wong

Subject: ***Development of Calaveras Dam Replacement Project (01CUW37401-A)***

I. Summary

The purpose of this memorandum is to document the development of the Calaveras Dam Replacement Project as a result of a comprehensive review of the overall Water System Improvement Program (WSIP) by the San Francisco Public Utilities Commission (SFPUC) in recent months. This memorandum will also serve as a basis for the Project Team to advance the project and prepare a Conceptual Engineering Report (CER) based on the work already completed and presented in the Alternative Analysis Report (AAR) prepared by the URS.

The Calaveras Dam Replacement Project (01CUW37401-A) will provide for the planning, design and construction of a replacement dam that can accommodate future enlargement (SFPUC, 2005).

- A new dam will be built immediately downstream of the existing dam to restore the reservoir's historic nominal capacity of 96,850 acre-feet. The new dam will replace the existing dam, which has been determined to be inadequate to withstand a major seismic event and placed under storage restriction by the California Department of Water Resources, Division of Safety of Dams (DSOD).
- The project will include new or rehabilitated outlet works for seismic safety, improved operations and maintenance, and accommodations for releases for environmental purposes.
- Additionally, the project will include a second pipeline[1] from the new dam to the Sunol Valley Water Treatment Plant (SVWTP) to provide delivery reliability in the event of a Hetch Hetchy outage. The new pipeline will provide an additional 70 million gallons per day (MGD) of capacity to the 90 MGD of the existing pipeline, and allow the full utilization of the SVWTP treatment capacity to supply 160 MGD from Calaveras Reservoir when needed.

II. Discussion

Calaveras Reservoir represents the largest local reservoir in the Regional Water System. As originally constructed in 1925, Calaveras Dam allows for retention of 96,850 acre-feet of local runoff in Alameda County. Since the winter of 2001, in response to safety concerns about the seismic stability of the dam and mandates from the DSOD, the SFPUC has lowered water levels in Calaveras Reservoir to a maximum level of elevation 705.45 feet[2], corresponding to 38,100 acre-feet, approximately 39% of its former capacity. The DSOD has indicated that it is allowing this interim operating level to accommodate the SFPUC's water needs, with the understanding that the SFPUC would pursue an aggressive schedule for the Calaveras Dam project, as part of its proposed capital improvement program.

---

[1] Alternatively, replace the existing pipeline with a new and larger pipeline.

[2] Elevations in this memorandum are based on USGS datum. Subtract 3.636 feet to convert to San Francisco Water Department (Crystal Springs) datum.

1. Alternative Evaluations Completed To Date

Since October 2003, the SFPUC has retained URS Corporation to provide professional engineering services for the conceptual engineering phase of the Calaveras Dam Project (SFPUC Agreement No. CS-716). The work includes the evaluation of alternatives to repair the existing Calaveras Dam or replace the dam with one of equal or enlarged capacity. Three main categories of alternatives have been studied:

- Category 1: Remediate or replace dam for the same reservoir storage – 96,850 acre-feet (normal maximum water surface elevation 756 feet).
- Category 2: Remediate or replace dam for increased reservoir storage – up to 420,000 acre-feet (normal maximum water surface up to elevation 900 feet).
- Category 3: Remediate or replace dam for the same reservoir storage (96,850 acre-feet) and retain option for future enlargement (up to a total of 420,000 acre-feet[3]). In this regard, the alternatives evaluated in Category 3, prior to enlargement, are similar to those in Category 1.

The alternatives were evaluated for the above three categories. Conceptual level designs, cost estimates, and construction schedules were then prepared. A number of technical memoranda (TM) were prepared:

- Evaluations of remedial alternatives and formulation of conceptual designs are presented in the Evaluation of Remedial Design Alternatives for Existing Dam, Draft TM 9.1 (URS, 2004a).
- Preliminary screening of replacement dam type alternatives and formulation of conceptual designs for those alternatives that passed the screening are presented in the Evaluation of Replacement and Enlarged Dam Alternatives, Draft TM 9.2 (URS, 2004b).
- Spillway and Outlet Works, Draft TM 7.0 (URS, 2004c) presents considerations for hydraulic structures associated with the various remedial and replacement dam alternatives.
- Evaluation of storage and bypass requirements during construction is presented in Operation of Reservoir/Storage and Bypass Requirements during Construction, Draft TM 11.1 (URS, 2004d).
- Construction cost estimates and schedules for selected remediation and replacement dam alternatives are presented in TM 13 (URS, 2005a).
- Environmental considerations including community disruption, biological issues, cultural issues, and water quality issues related to the alternatives are presented in TM 8 (URS, 2005b).

The above TMs, including the conceptual design of the remediation and replacement dam alternatives were presented to the Calaveras Technical Advisory Panel (CTAP) on July 27-29, 2004, and to the DSOD on August 26, 2004.

---

[3] The maximum storage capacity of 420,000 acre-feet is based on considerations of the active Calaveras fault. The fault passes through a low saddle located west of the dam site and limits the maximum reservoir level. It is not considered feasible to construct a saddle dam across the active Calaveras fault.

2. *Alternative Analysis Report (AAR)*

The results of the alternative analyses and evaluations, and recommendations of proposed preferred alternatives were presented in TM 9.3 – Evaluation of Dam Remediation and Replacement Alternatives (URS, 2005c). The approach, analysis and information presented in this TM are based on SFPUC Procedure No. PD 3.3, Alternatives Analysis and Evaluation, dated August 18, 2003. Comments received from CTAP and DSOD on the work presented in the above TMs were incorporated, where applicable, in the preparation of TM 9.3.

The contents of TM 9.3 fulfill the requirements of an Alternative Analysis Report (AAR) specified in Procedure No. PD 3.3. As such, TM 9.3 is considered the equivalent of an AAR and shall be referred as the Project AAR hereinafter.

As summarized in the AAR, alternatives analyses were conducted for the five following criteria:

- environmental impacts
- operational flexibility, maintainability, and reliability
- implementability
- cost
- dam safety approval.

Each of the criteria was broken into definable contents that could be quantified for comparison of the alternatives in a matrix format. A ranking system consisting of criteria weighting factors and scoring rationale was developed to provide a rational basis for evaluating the alternatives within the project categories to assist in identifying the proposed preferred alternative. The scoring rationale and weighting factors were applied to the results of the alternative analysis for the project categories.

The results indicate that for Category 1 a downstream earthfill replacement dam (1Ca) has the highest ranking. The earth- and rockfill dam (2Cb) has the highest ranking for Category 2. In Category 3, the preferred alternative is a downstream earthfill replacement dam with open spillway (3Ca).

Essentially, the results indicate that regardless of (1) the size of the reservoir, i.e. Category 1 versus Categories 2 or 3; or (2) single versus staged construction, i.e. Category 1 or 2 versus Category 3, the preferred alternative is to:

- replace instead of remediate the existing dam,
- with a new earthfill dam,
- downstream of the existing dam,
- with an open-chute spillway.

The AAR and the above findings presented to the CTAP on November 1-2, 2004, and to the DSOD on December 16, 2004. Based on the general concurrence received from the CTAP and DSOD, the AAR and the findings were presented to the SFPUC Management Steering Committee on December 21, 2004.

3. *New Water System Improvement Program (WSIP)*

In October 2004, the SFPUC initiated a comprehensive review of the entire capital improvement program. Approved by the Commissioners at SFPUC on February 8, 2005, the new Water System Improvement Program (WSIP) was developed following a series of six public workshops that evaluated the originally proposed 37 regional projects and identified specific overall program goals for seismic reliability, water quality, water supply and delivery reliability.

As part of this overall program review and re-scoping of projects, the following options were considered for the Calaveras Dam Project: (1) Calaveras Seismic Project with nominal capacity of 96,850 acre-feet, and (2) Calaveras Water Supply Project with an enlarged reservoir of 200,000 acre-feet. These options were was presented and discussed at a SFPUC hearing on January 13, 2005. It became apparent that a number of issues related to alternatives and options to achieve the goals for water supply at the program level would remain undecided and potential delays could be encountered in a reservoir enlargement project. Because there is an immediate and urgent need to replace the current water storage deficit resulting from DSOD's restriction on reservoir level, the final program submitted to the Commission shifted the main focus to the seismic reliability at Calaveras. The project that is included in the new WSIP is the Calaveras Dam Replacement Project. The new replacement dam will restore the historic nominal capacity of 96,850 acre-feet and can accommodate future enlargement.

4. *Calaveras Dam Replacement Project*

The scope of the Calaveras Dam Replacement Project will include the following:

- Replacement of the existing dam with a new earthfill dam located downstream of the existing dam.
- The new dam would have a nominal reservoir storage of 96,850 acre-feet (normal maximum water surface elevation, NMWS, Elevation = 756 feet).
- The new dam would accomodateenlargement up to 386,000 acre-feet[4] (NMWS Elevation = 890 feet[5]).
- The project will include new or rehabilitated outlet works for seismic safety, improved operations and maintenance, and accommodations for water releases for environmental purposes.
- Additionally, the project will include a second pipeline[6] from the new dam to the SVWTP to provide delivery reliability in the event of a Hetch Hetchy outage. The new pipeline will provide an additional 70 MGD of capacity to the 90 MGD of the existing pipeline, and allow the full utilization of the SVWTP treatment capacity to supply 160 MGD from Calaveras Reservoir when needed.

It is assumed that there will be no changes in reservoir operations when the project is re-built except as required by the conditions set forth in the 1997 Memorandum of Understanding (MOU) established bertween the California Department of Fish and Game (CDFG) and SFPUC.

---

[4] Core and filter dimensions within the new dam will be constructed to accommodate enlargement of the dam to 386,000 acre-feet.

[5] Approximate invert elevation of the Alameda Creek Diversion Tunnel.

[6] Alternatively, replace the existing pipeline with a new and larger pipeline.

5. *Conceptual Engineering Report (CER)*

The AAR (TM 9.3) completed to date is considered adequate to address the needs of the alternative analysis and evaluation of the Calaveras Dam Replacement Project. It will serve as a basis for the preparation of the Conceptual Engineering Report (CER) for the Project. This CER will consist of two volumes: Volume I – Dam and Appurtenant Strucstures; and Volume II – Conveyance Facilities. Volume I will also inlcude an appendix covering the stability analysis of an enlarged dam.to store 386,000 acre feet. This appendix is provided solely for the purpose to demonstrate that, from a technical standpoint, the new replacement dam can be enlarged to store 386,000 acre-feet. The CTAP and DSOD will need to review the technical aspects of the enlargement in order to obtain their concurrence that the dam can be enlarged as presented in the appendix.

6. *Path Forward*

The information presented in this memorandum was discussed and general concurrence was reached during the Management Steering Committee Meeting on March 1, 2005. The project team is now tasked to move forward immediately with the completion of Calaveras Dam Replacement Project CER.

III. References

SFPUC (2005). Water System Improvement Program – Program Description, Draft, February.

URS (2004a). Calaveras Dam Conceptual Engineering, Evaluation of Remedial Design Alternatives for Existing Dam (Task 9.1), Draft, July.

URS (2004b). Calaveras Dam Conceptual Engineering, Evaluation of Replacement and Enlarged Dam Alternatives (Task 9.2), Draft, July.

URS (2004c). Calaveras Dam Conceptual Engineering, Spillway and Outlet Works (Task 7), Draft, July.

URS (2004d). Calaveras Dam Conceptual Engineering, Operation of Reservoir/Storage and Bypass Requirements During Construction (Task 11.1), Draft, July.

URS (2005a). Calaveras Dam Conceptual Engineering, Cost Estimates of Alternatives (Task 13), Final, March.

URS (2005b). Calaveras Dam Conceptual Engineering, Environmental Constraints Evaluation of the Proposed Dam Alternatives, (Task 8), Final., April.

URS (2005c). Calaveras Dam Conceptual Engineering, Evaluation of Dam Remediation and Replacement Alternatives, (Task 9.3), Final, March..

Appendix B

Reservoir Operations Plan

TABLE OF CONTENTS

Appendix B **Reservoir Operations Plan B-1**

B-1 Reference Documents B-1
B-2 General B-1
B-3 Basic Operating Principles B-2
B-4 Fishery Considerations B-3
B-5 Normal Operations B-4
B-6 Extraordinary Operations B-5

B-1 REFERENCE DOCUMENTS

The Reservoir Operations Plan for the Calaveras Dam Replacement Project presented herein is prepared based on the following documents provided by the San Francisco Public Utilities Commission (SFPUC).

- "Water System Improvement Program Prepared for the Programmatic Environmental Impact Report" by the SFPUC dated February 28, 2005 for a more detailed description of the overall system.
- "The Operation and Management of the San Francisco Water System" as prepared by Leo Bauer February 14, 2002 and expanded June 5, 2002
- Memorandum from Norman H. Lougee, SFPUC to CDFG dated October 11, 1991.
- Memorandum of Understanding between the City and County of San Francisco and the California Department of Fish and Game regarding water release and recapture facilities for purposes of improving native fisheries on Alameda and Calaveras Creeks signed by the SFPUC on July 30, 1997 and the CDFG on July 25, 1997.

B-2 GENERAL

It is important to note that this reservoir operations plan should be considered a living document and subject to change based on changing operational needs and regulatory requirements.

Calaveras Reservoir is one component of the San Francisco Public Utilities Commission (SFPUC) water supply system. This water system supplies an average of approximately 260 million gallons per day (mgd) to retail customers within the City and County of San Francisco and to wholesale customers in Alameda, Santa Clara and San Mateo Counties. Nearly 2.4 million people rely entirely or in part on water supplied by the SFPUC system to meet their daily water needs. The Hetch Hetchy Project on the Tuolumne River watershed in the Sierra Nevada mountains approximately 160 miles east of San Francisco supplies approximately 80-85% of this total demand. The remainder is supplied by San Francisco's Bay Area (or "local") water system in Alameda and San Mateo Counties.

Calaveras Reservoir is located on Calaveras Creek, a tributary to Alameda Creek in Alameda and Santa Clara Counties. With a rated capacity of 96,850 acre-feet[1] it provides over 40% of the SFPUC's usable local storage. Because of its size, Calaveras Reservoir is the water supply system's primary local counterpart to the Hetch Hetchy supply. If the Hetch Hetchy supply is lost or has to be diverted due to a water quality problem, water from Calaveras Reservoir is a major source used to meet system demands.

The watershed drainage area at Calaveras Dam is 98.4 square miles. Water production varies widely from year to year, but the runoff is estimated to average about 36,000 acre-feet per year (32 mgd). Runoff from upper Alameda Creek (drainage area 35 square miles) can also be diverted into Calaveras Reservoir via a diversion tunnel. It is estimated that this diversion contributes an additional 6,000 acre-feet per/year (5 mgd).

---

[1] The current storage capacity is estimated to be approximately 92,000 acre-feet after accounting for accumulated sediment within the reservoir. The storage capacities provided elsewhere in this document are based on the rated capacity; that is, they do not deduct the estimated volume of accumulated sediment.

B-3 BASIC OPERATING PRINCIPLES

SFPUC operations are based on numerous operational requirements described in stipulations and agreements, authorizing legislation and regulatory requirements. Additionally, operations are guided by judgment, strategies, and historical experience. The primary operational approach is to provide reliable service by:

- Maximizing carryover storage; and
- Maximizing local resources while maintaining maximum local storage to provide system reliability.[2]

Some of the key requirements are:

- Maximize the use of the Bay Area (local) water system before utilizing Hetch Hetchy supply in accordance with provisions of the Raker Act that authorized the construction of the Hetch Hetchy Project within Yosemite National Park.
- Operate to minimize the potential for an increase in turbidity in the Hetch Hetchy supply. (Hetch Hetchy water meets the requirements of filtration avoidance as specified in the Surface Water Treatment Rule. Turbidity is continually monitored to ensure that Hetch Hetchy water stays in compliance.)

In order to comply with these requirements, there are a number of basic operating principles that SFPUC utilizes in the operation of the Bay Area portion of its system that directly or indirectly affect the operation of Calaveras Reservoir[3]

- The Sunol Valley Water Treatment (SVWTP) shall be maintained at or above the minimum plant rate (10 mgd) at all times.
- The Harry Tracy Water Treatment Plant shall be maintained at or above the minimum plant rate (20-25 mgd) at all times.
- The Coast Range Tunnel rate shall be maintained at no less than 70 mgd (preferably no less than 100 mgd) at all times.
- The goal is that all Water Supply and Treatment Division reservoirs shall be full by the cessation of the rainy season (generally sometime in early to mid spring).
- Each reservoir shall be at a predetermined level at the commencement of the rainy season on November 1st and shall be maintained at this level through the rainy season.
- There shall be no uncontrolled spills from any of the Peninsula reservoirs.

---

[2] Refer to the "Water System Improvement Program Prepared for the Programmatic Environmental Impact Report" by the SFPUC dated February 28, 2005 for a more detailed description of the overall system.

[3] These operating principles are taken from "the Operation and Management of the San Francisco Water System" as prepared by Leo Bauer February 14, 2002 and expanded June 5, 2002

- There shall be a minimum of changes in the flow rate from Hetch Hetchy that requires the return to service of a section(s) of the San Joaquin Pipelines that had previously been out of service.
- Be flexible.

B-4 FISHERY CONSIDERATIONS

Calaveras Reservoir operations are also subject to agreements with the California Department of Fish and Game (CDFG) to protect fish within the reservoir and to maintain and improve fish habitat in Calaveras Creek and portions of Alameda Creek downstream of Calaveras Dam. Certain of these provisions have been implemented. Others have not yet been implemented because of the storage restriction ordered by DSOD at the reservoir. In addition, the SFPUC and CDFG are reviewing options associated with fish passage of land-locked steelhead trout within the reservoir and improving habitat downstream of the dam. The SFPUC is also in the process of installing a hypolimnetic oxygenation system to improve water quality at lower levels within the reservoir.

Current Operational Considerations. In accordance with a 1991 memorandum from the SFPUC to CFDG[4], the SFPUC installed fish screens on Adits 2 and 3 and established a minimum pool elevation of 690.0 (approximately 25,700 acre-feet) to minimize the entrainment of fish into the intake. The memorandum provides for an exception "during a natural disaster such as a major earthquake or an unexpected water supply system failure" when "maximum withdrawal of water from Calaveras Reservoir may be required independent of lake level and time of year."

Understanding Not Yet Implemented. In 1997, the SFPUC and CDFG signed a Memorandum of Understanding[5] (MOU) regarding "Water releases and Recapture Facilities for the Purposes of Improving Native Fisheries on Alameda Creek". Among a number of provisions, the parties agreed:

- *"Following completion of project level environmental review and permitting approvals, the SFPUC may construct water system improvements needed to release water from Calaveras Reservoir and recapture this water in the vicinity of the SVWTP for consumptive use in the SFPUC service area. .... Following implementation of the preferred alternative, the SFPUC shall proceed with due diligence to make water releases in order to create the following flow regimes in Calaveras and Alameda Creeks."* (Four flow regimes are detailed for specific locations and times of year.)
- *"The SFPUC shall maintain historical Calaveras Reservoir stratification conditions. .... The SFPUC shall use best efforts to maintain 30,000 acre feet of water in storage in late summer. The SFPUC may reduce spawning and rearing flows in order to preserve cold water releases from the Calaveras Reservoir throughout the summer, after consulting with, and obtaining the approval of, CDFG."*

---

[4] Memorandum from Norman H. Lougee, SFPUC to CDFG dated October 11, 1991.

[5] Memorandum of Understanding between the City and County of San Francisco and the California Department of Fish and Game regarding water release and recapture facilities for purposes of improving native fisheries on Alameda and Calaveras Creeks signed by the SFPUC on July 30, 1997 and the CDFG on July 25, 1997.

- *"The CDFG agrees to cooperate and support the SFPUC's efforts to obtain necessary permits and approvals needed to implement the preferred alternative, including but not limited to ....."* (It then lists section 1601, section 13000 and section 490 permits).

The MOU has not been fully implemented because of the current limitations in storage. It is likely that the provisions of this MOU will be modified prior to the completion of the Calaveras Dam Replacement Project as a result of ongoing fisheries studies and the installation of the oxygenation system within the reservoir.

B-5 NORMAL OPERATIONS

At the Cessation of the Rainy Season. Once SFPUC operations is comfortable that the rainy season is effectively over (sometime in March or April depending on yearly weather patterns and subjective judgment) Calaveras Reservoir is operated in so far as possible to fill and thereby maximize "local" storage at the start of the heavy demand period. Upon the completion of the Calaveras Dam Replacement Project, this will mean filling the reservoir to elevation 756.2 feet, or 31.5 billion gallons (96,850 acre-feet). Water in excess of that needed to fill Calaveras and supply the SVWTP can be transferred to help fill San Antonio Reservoir. If transmission capacity is available, it can also be used to augment storage in Crystal Springs and San Andreas reservoirs.

Through the Summer. Once Calaveras Reservoir reaches its maximum level, deliveries to the SVWTP are minimized in order to maximize the amount of water available in the event of a partial or total disruption of the Hetch Hetchy supply. The SVWTP is operated at its minimum plant rate (10 mgd) utilizing the combination of Calaveras and/or San Antonio and, occasionally, Hetch Hetchy flow. If system demand is greater than the total of Hetch Hetchy delivery plus minimum operation of the Sunol Valley and Harry Tracy Water Treatment Plants, a combination of Calaveras and/or the other local reservoirs are called upon to meet the demand.

At the present time, the SFPUC does not normally make releases to Calaveras Creek below Calaveras Dam. However, the Calaveras Dam Replacement Project includes a small diameter valve for making low level releases to the creek to facilitate implementation of the 1997 MOU (including amendments).

Early Fall Drawdown. In September the SFPUC completes an operational plan to determine how to draw down the local reservoirs to their planned winter elevation by November 1. Upon the completion of the Calaveras Dam Replacement Project, (and subject to reevaluation), the drawdown at Calaveras is expected to be to approximately elevation 746 feet, or 27 billion gallons (82,850 acre-feet).

Though the Rainy Season. Throughout the rainy season, Calaveras Reservoir will be operated to capture winter season storm runoff while minimizing the potential for uncontrolled spills. In as much as possible, the reservoir will be maintained at its planned winter elevation by utilizing runoff to help meet system water demands by diversion to the SVWTP. The capacity of the existing pipeline between Calaveras Dam and the SVWTP is 90 mgd. In times of excess runoff, the gates at the head tunnel at the Alameda Creek diversion tunnel are closed, and, if necessary, releases are made from the dam directly to Calaveras Creek. While there are no flood control requirements at Calaveras Dam, releases should be timed so as not to exacerbate downstream flooding.

Alameda Creek Diversion Dam. The existing Alameda Creek Diversion Dam diverts water from the upper Alameda Creek watershed to Calaveras Reservoir via the 9,800-feet long Alameda Creek Diversion Tunnel. During normal operations, flow in Alameda Creek up to the tunnel capacity of 730 cfs is diverted to Calaveras Reservoir. Gates are used to shut off flow to the tunnel when it is unnecessary or undesirable to divert water to Calaveras.

The SFPUC is investigating the potential to modify the operation at the diversion dam to improve fisheries while continuing to meet its water supply obligations.

B-6 EXTRAORDINARY OPERATIONS

Turbidity Event. A "turbidity event" occurs whenever the Hetch Hetchy supply fails to meet the requirements for filtration avoidance. Upon determination that the Hetch Hetchy supply does not meet filtration avoidance requirements there are a number of considerations associated with the use and/or disposal of this water. While details are outside of the scope of this Calaveras Reservoir Operations Plan, during such an event Hetch Hetchy water may be: discharged to Alameda Creek; sent to San Antonio Reservoir; and/or, treated for system use at the SVWTP. For a longer term event, releases may also be reduced or suspended from the Hetchy system in order to conserve water.

During a turbidity event, the SVWTP becomes a primary supply for system water, utilizing some combination of Calaveras, San Antonio and Hetch Hetchy water as its sources. Calaveras can supply no more than 90 mgd of the total 160 mgd capacity because of supply pipeline limitations.

When starting full, Calaveras can supply 90 mgd of water continuously for about 250 days utilizing Adits 1, 2 and/or 3 until the elevation 690.0 feet is reached. In an emergency, water can be drawn down further, (but at a reduced rate) utilizing the drain valve at the bottom of the intake tower.

Drought. The SFPUC water supply system is relatively unaffected by short-term drought events because of a relatively stable source or supply and the significant carryover storage in the system. Over a longer term drought, (the system design drought is 8½ years) the SFPUC gradually reduces the carryover storage from the targeted level in all of its reservoirs in order to meet system needs. At Calaveras, this means that the reservoir will be gradually drawn down during the course of the drought such that it enters the rainy season with less and less water compared to its target storage of 27 billion gallons. At the end of the design drought, Calaveras Reservoir (and all of the reservoirs in the SFPUC system) would be virtually depleted of its active storage.

Dam Safety. DSOD requires that dams under its jurisdiction have the ability evacuate the reservoir quickly, should an unsafe condition develop at the dam. The major concern at Calaveras is seismic performance. The operations plan for Calaveras Dam will provide for a detailed inspection of the facility following any significant seismic event in the vicinity of the dam. The reservoir will be immediately drawn down to a level determined to be safe in the event the inspection shows any damage to the embankment.

DSOD guidelines for emergency drawdown of large reservoirs are to have the capability to:

- Lower the reservoir by an amount equal to 10% of the hydraulic head behind the dam in ten days. Hydraulic head is defined as the elevation difference between the normal maximum water surface and the deadpool surface.
- Evacuate the reservoir to deadpool elevation within 120 days.

Calaveras Dam has a hydraulic head of 147 feet (elevation 756.2-609.1 feet). Approximately 19,800 acre-feet are stored in the top 14.7 feet (10% of the head). An average release rate of 996 cfs is needed to evacuate this quantity of water over a ten day period. The outlet works system (as rehabilitated in 1991-1992) was designed to meet this requirement.

Appendix C

Special Status Species with Potential to Occur in the Project Area

Table C-1
Special Status Species with Potential to Occur in the Project Area

Scientific Name	Common Name	Status		
		Fed	**CA**	**CNPS**
Plants				
Acanthomintha lanceolata	Santa Clara thorn mint			4
Astragalus tener var. tener	Alkali milk-vetch			1B
Atriplex depressa	Brittlescale			1B
Atriplex joaquiniana	San Joaquin saltbush			1B
Balsamorhiza macrolepis var. macrolepis	Big-scale balsamroot			1B
Campanula exigua	Chaparral harebell			1B
Campanula sharsmithiae	Sharsmith's harebell			1B
Calochortis umbellatus	Oakland star tulip			4
Castilleja affinis	Tiburon Indian Paintbrush	E	T	1B
Centromadia parryi ssp. congdonii	Congdon's tarplant			1B
Chorizanthe robusta var. robusta	Robust spineflower	E		1B
Cirsium fontinale var. campylon	Mt. Hamilton thistle			1B
Cirsium walkerianum	Alameda County thistle			4
Clarkia breweri	Brewer's clarkia			4
Clarkia franciscana	Presidio clarkia			4
Collomia diversifolia	Serpentine collomia			4
Coreopsis hamiltonii	Mt. Hamilton coreopsis			1B
Delphinium californicum ssp. interius	Hospital Canyon larkspur			1B
Dirca occidentalis	Western leatherwood			4
Dudleya setchellii	Santa Clara Valley dudleya	E		1B
Eriogonum luteolum var. caninum	Tiburon buckwheat			4
Eriophyllum jepsonii	Jepson's woolly sunflower			4
Erodium macrophyllum	Round-Leaved Filaree			2
Eryngium aristulatum var. hooveri	Hoover's button-celery			1B
Fritillaria agrestis	Stinkbells			4
Fritillaria falcata	Talus fritillary			1B
Fritillaria liliacea	Fragrant fritillary			1B
Helianthella castanea	Diablo helianthella			1B
Lasthenia conjugens	Contra Costa goldfields	E		1B
Lepidum latipes	Dwarf pepper-grass			4
Malacothamnus arcuatus	Arcuate bush mallow			1B
Malacothamnus hallii	Hall's bush mallow			1B
Monarsella villosa ssp. globosa	Robust Monardella			1B
Navarretia prostrata	Prostrate navarretia			1B
Perideridia gairdneri	Gairdner's yampah			1B
Phacelia phacelioides	Mt. Diablo phacelia			1B
Plagiobothrys glaber	Hairless popcorn-flower			1A

Table C-1
Special Status Species with Potential to Occur in the Project Area

Scientific Name	Common Name	Status		
		Fed	CA	CNPS
Plagiobothrys myosotoides	Forget-me-not popcorn flower			3
Quercus lobata	Valley oak			4
Ranunculus lobbii	Lobb's aquatic buttercup			4
Ribes divaricatum var. pubiflorum	Straggly gooseberry			4
Sanicula saxitilis	Rock sanicle		R	1B
Sidalcea malachroides	Maple-leaved checkerbloom			1B
Streptanthus albidus ssp. albidus	Metcalf Canyon jewel-flower	E		1B
Streptanthus albidus ssp. peramoenus	Most beautiful jewel-flower			1B
Streptanthus callistus	Mt. Hamilton jewelflower			1B
Streptanthus hispidus	Mt. Diablo jewelflower			1B
Stylocline amphibole	Mt. Diablo cottonweed			4
Trifolium amoenum	Showy Indian clover			1A
Tropidocarideum capparideum	Caper-fruited tropidocarpum			1A
Aquatic Animals				
Archoplites interruptus	Sacramento perch		SC	
Lampetra tridentate	Pacific lamprey		SC	
Oncorhynchus mykiss irideus	Resident Rainbow Trout	PT		
Reptiles and Amphibians				
Ambystoma californiense	California tiger salamander	T		
Cnemidophorus tigris multiscutatus	Coastal western whiptail	SC		
Emys (=Clemmys) marmorata	Western Pond Turtle	SC	SC	
Masticophis lateralis euryxanthus	Alameda whipsnake	T	T	
Phrynosoma coronatum (frontale)	Coast (California) horned lizard		SC	
Rana aurora draytonii	California red-legged frog	T	SC	
Rana boylii	Foothill yellow-legged frog		SC	
Birds				
Accipiter cooperii	Cooper's hawk		SC	
Accipiter striatus	Sharp-shinned hawk		SC	
Aechmophorus occidentalis	Western grebe		SA	
Agelaius tricolor	Tricolored blackbird	SC	SC	
Aquila chrysaetos	Golden eagle		SC	
Ardea herodias	Great blue heron			
Asio flammeus (nesting)	Short-eared owl		SC	
Athene cunicularia	Burrowing owl		SC	
Branta canadensis leucopareia	Aleutian Canada goose	D		
Buteo regalis (wintering)	Ferruginous hawk	SC	SC	
Circus cyaneus	Northern harrier		SC	
Elanus leucurus	White-tailed kite			

Table C-1
Special Status Species with Potential to Occur in the Project Area

Scientific Name	Common Name	Status		
		Fed	**CA**	**CNPS**
Eremophila alpestris actia	California horned lark		SC	
Falco mexicanus	Prairie falcon		SC	
Falco peregrinus anatum	American peregrine falcon	D	E	
Haliaeetus leucocephalus	Bald eagle	T	E	
Pandion haliaetus	Osprey		SC	
Pelecanus erythrorhynchos	American white pelican		SC	
Invertebrates				
Adela oplerella	Opler's longhorn moth			
Branchinecta lynchi	Vernal pool fairy shrimp	T		
Calicina (=sitalcina) minor	Edgewood blind harvestman			
Euphydryas editha bayensis	Bay checkerspot butterfly	T		
Lepidurus packardi	Vernal pool tadpole shrimp	E		
Speyeria callipe callipe	Callippe silverspot butterfly	E		
Mammals				
Antrozous pallidus	Pallid bat	SC	SC	
Corynorhinus townsendii townsendii	Townsend's western big-eared bat	SC	SC	
Dipodomys heermanni berkeleyenis	Berkeley kangaroo rat			
Eumops perotis	Western mastiff bat	SC	SC	
Myotis ciliolabrum	Small-footed myotis	SC		
Myotis evotis	Fringed myotis	SC		
Myotis thysanodes	Fringed myotis	SC		
Myotis volans	Long-legged myotis	SC		
Taxidea taxus	American badger		SA	

Status Abbreviations:

E = Endangered
T = Threatened
PT = Proposed for Listing as Threatened
R = Rare
SC = Species of Concern
SA = Special Animal
D = De-listed
CNPS = California Native Plant Society
1A = CNPS Plants presumed extinct in CA
1B = CNPS Plants rare and endangered in CA, more common elsewhere
4 = CNPS Plants of limited distribution (a "watch list")

Appendix D

Stability and Seismic Deformation Analyses of Replacement Dam

TABLE OF CONTENTS

Appendix D D-1

D-1 Purpose and Objectives D-1
D-2 Stability Analysis D-1
  D-2.1 Analysis Section D-1
  D-2.2 Material Properties D-2
  D-2.3 Analysis Method D-3
  D-2.4 Results of Static and Pseudo-Static Analyses D-3
D-3 Dynamic Response Analysis D-4
  D-3.1 Analysis Method D-4
  D-3.2 Finite Element Model D-4
  D-3.3 Dynamic Material Properties D-5
  D-3.4 Dynamic Response Results D-5
  D-3.5 Earthquake-Induced Embankment Deformation D-6
  D-3.6 Calculated Displacements D-6
D-4 Conclusions Regarding Earthquake-Induced Displacements D-6

Tables

Table D-1 Soil Strength Parameters Used for Static Stability Analysis - Replacement Dam

Table D-2 Summary Soil Strength Parameters Used in Analysis - Cofferdam

Table D-3 Static Stability Analysis Results

Table D-4 Dynamic Soil Properties

Figures

Figure D-1 Replacement Dam, Long-Term and Emergency Rapid Drawdawn Analysis Results

Figure D-2 Replacement Dam, Pseudo-Static Analysis Results

Figure D-3 Cofferdam Stability Analysis Results

Figure D-4 Design Earthquake, Horizontal Fault Parallel Time History

Figure D-5 Two-dimensional Finite Element Model for Dynamic Response Analysis

Figure D-6 Modulus Reduction and Damping Curves Used for Dynamic Analysis

Figure D-7 Horizontal Acceleration Time Histories, Near Upstream Toe Locations

Figure D-8 Horizontal Acceleration Time Histories, Upstream Slope Locations

Figure D-9 Horizontal Acceleration Time Histories, Dam Crest Locations

Figure D-10 Horizontal Acceleration Time Histories, Downstream Slope Locations

Figure D-11 Horizontal Acceleration Time Histories, Near Downstream Toe Locations

Figure D-12a Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #1, Upstream

Figure D-12b Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #2, Upstream

Figure D-12c Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #3, Upstream

Figure D-13a Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #1, Downstream

Figure D-13b Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #2, Downstream

Figure D-13c Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #3, Downstream

D-1 PURPOSE AND OBJECTIVES

This appendix presents the results of the static stability and seismic deformation analyses of the Calaveras Replacement Dam. The objective of these analyses was to evaluate the stability of the dam under various loading conditions and estimate the dynamic response and potential earthquake-induced deformations of the dam.

D-2 STABILITY ANALYSIS

The stability of the replacement dam was evaluated under the following loading conditions:

- Steady-state Seepage: Safety factors for steady-state seepage conditions were computed using effective strength parameters and the reservoir at normal maximum water surface (NMWS) elevation 756.2.
- Rapid Reservoir Drawdown: The reservoir surface is drawn from the NMWS to dead-pool elevation of 663[1] feet for emergency drawdown. Pore pressure dissipation was not allowed within the earthfill zones. The analysis used the three-stage limit equilibrium method, based on Lowe and Karafiath (1960) and subsequent modifications by Duncan, Wright and Wong (1990).
- Pseudo-static: Pseudo-static stability analyses were performed with the reservoir at NMWS to calculate yield accelerations[2] for use in estimating the earthquake-induced permanent displacements of potential sliding masses (also referred to as sliding blocks herein).
- Cofferdam Excavation: Stability analysis of the downstream excavation slope of the existing dam (cofferdam) was performed using effective strength parameters for the reservoir water surface at its maximum restricted level at elevation 705. The excavated downstream slope is a temporary condition during construction of the replacement dam.

D-2.1 Analysis Section

Stability analyses were performed for the maximum section of the replacement dam (Figure 7-4 in the CER text). The upstream and downstream shells of the dam are earthfill constructed of Temblor Sandstone (Zone 4). The core of the dam consists of alluvial sandy clayey soils (Zone 1).

The phreatic surface within the new Replacement Dam was modeled along the chimney and blanket drain zones. The location of the phreatic surface within the existing dam/cofferdam was based on 2002 piezometric levels as shown in Olivia Chen Consultants' Report on the Seismic Stability of Calaveras Dam (OCC, 2003).

---

[1] This is the elevation of Adit No. 1, which is west of the section for analysis.

[2] The yield acceleration is the horizontal seismic coefficient that causes a factor of safety of 1.0 for a sliding mass.

D-2.2 Material Properties

The strength properties of the embankment and foundation materials used in the stability analyses are presented in Table D-1. Strength parameters for the Temblor Sandstone shell (Zone 4) and clay core (Zone 1) are based on the results from the isotropically-consolidated-undrained (ICU) triaxial tests performed during the field investigation (URS, 2005a). Effective strength parameters were developed from a linear regression of the p' (effective mean confining pressure) - q (shear stress) data. The intercept (d'_{Kf}) and slope (ψ'_{Kf}) of the regression line were converted to Mohr-Coulomb parameters (c', ϕ') using the relationships:

$$c' = d'_{Kf}/\cos\phi' \quad \& \quad \phi' = \sin^{-1}[\tan(\psi'_{Kf})].$$

Effective strength parameters for the Temblor Sandstone shell and clay core are 0.56 ksf and 36° and 0.35 ksf and 28°, respectively. Total strength parameters (c_R, ϕ_R) were back-calculated based on an assessment of the σ'_{fc} - τ_{ff} data, using the relationships:

$$d_{Kc=1} = \frac{c_R.\cos\phi_R.\cos\phi'}{1 - \sin\phi_R}$$

$$\psi_{Kc=1} = \tan^{-1}\left(\frac{\sin\phi_R.\cos\phi'}{1 - \sin\phi_R}\right)$$

Total strength parameters for the Temblor Sandstone shell and clay core are 1.9 ksf and 23° and 0.43 ksf and 15°, respectively.

The foundation strength parameters were modeled as those of the Franciscan Complex mélange rather than the higher strength Temblor Sandstone. The effective cohesion and friction angle for the foundation were based on the relationships developed for the mélange at Scott Dam (Goodman, et al., 2000). The strength parameters developed for Scott Dam are a function of the proportion of higher strength blocks within the mélange rock mass, which at Calaveras Dam is estimated at approximately 30 percent (URS, 2005b). On this basis, an effective cohesion and friction angle of 1.4 ksf and 38°, respectively, were used as a lower bound estimate of the strength of the Calaveras Dam foundation.

Table D-1
Soil Strength Parameters Used for Stability Analysis - Replacement Dam

Material	Unit Weight pcf		Total Stress Parameters		Effective Stress Parameters	
	Moist	Saturated	c, ksf	ϕ, deg	c', ksf	ϕ', deg
Clay Core	128	130	0.43	15	0.35	28
Filter/Drain	125	130	-	-	0	40
Temblor Sandstone Shell	130	135	1.9	23	0.56	36
Foundation - Franciscan mélange	-	150	-	-	1.4	38

The stability of the new embankment should not depend on the strength of the existing embankment materials, and thus these materials were not modeled in the stability analysis of the replacement dam. For the cofferdam, the strength properties used in the stability analysis for the downstream excavated slope are presented in Table D-2 and are based on URS (2004a).

Table D-2
Summary of Soil Strength Parameters Used in Analysis - Cofferdam

Embankment and Foundation Soils			Unit Weight		Effective Stress Parameters	
			moist	saturated	c'	ϕ'
Zone	Subzone	Zone Descriptions	pcf	pcf	ksf	degrees
II	M	Dumped Weathered Rock Fill (Mixed)	125	135	0	33
	US	Dumped Weathered Rock Fill, "Hard" Rock Fill, and Rolled Fill with Zones of Weathered Rockfill and Disturbed Hydraulic Fill (Post-1918)	129	139	0	32
	TD	Dumped Weathered Rock Fill (Training Dike)	125	-	0	31
IV	-	Rolled Fill Core (Primarily Fine-Grained)	116	137	0.33	30
V	G	Mixed Dumped and Sedimented Hydraulic Fill (Primarily Granular) (Pre-1918)	130	135	0	31
VI	G - emb	Disturbed and Mixed Hydraulic, Dumped, and Rock Fill (Primarily Granular) (Below Embankment)	130	134	0	32
	R	Disturbed Weathered Rock Fill	130	134	0	32
VII	-	Sedimented Hydraulic Fill (Primarily Fine-Grained) (Pre-1918)	-	135	0	32
VIII	-	Alluvium (Primarily Granular)	-	134	0	34

D-2.3 Analysis Method

The stability analyses were performed using the computer program UTEXAS3 (Wright, 1991). Spencer's limit-equilibrium procedure was used for the computation of factors of safety. Potential sliding surfaces were identified using the iterative searching routines in the program.

For the pseudo-static analyses to calculate the yield acceleration (k_y), a horizontal force is applied to the potential sliding mass to represent the earthquake-induced load. This analysis computes the k_y value.

D-2.4 Results of Static and Pseudo-Static Analyses

Static analysis results for the replacement dam are presented in Table D-3, along with the corresponding minimum allowable safety factors. The sliding surfaces for the replacement dam are shown on Figure D-1. The results of the stability analyses show that the calculated factors of safety exceed the minimum required factors of safety.

Figure D-2 shows various potential sliding surfaces through the upstream and downstream slopes and the associated yield accelerations. The computed yield accelerations are greater for the potential sliding surfaces at the higher elevations in the dam than the sliding surfaces at lower elevations. The k_y values range from 0.27g to 0.37g in the upstream slope and from 0.33g to 0.45g in the downstream slope.

Table D-3
Static Stability Analysis Results

Loading Condition	Slope	Static SF	Minimum SF[1]
Steady-state Seepage	Downstream	1.93	1.5
Emergency Rapid Drawdown	Upstream	1.45	1.2
Cofferdam - Construction Excavation Slope	Downstream	1.42	1.3

[1] See Section 3.4 of CER text.

Figure D-3 shows the sliding surface and factor of safety for the temporary downstream excavation slope of the cofferdam. The factor of safety exceeds the minimum required factor of safety.

D-3 DYNAMIC RESPONSE ANALYSIS

The purpose of the dynamic analysis was to evaluate the seismic response of the replacement embankment during the design earthquake, including assessing the induced stresses and accelerations. The analysis provided estimates of the driving inertia forces induced in the sliding masses identified in the pseudo-static analysis.

The acceleration time history for the design earthquake was developed based on the deterministic 84th-percentile ground motion estimated from a Maximum Credible Earthquake (MCE), a **M**7¼ event on the Calaveras fault. Development of the acceleration response spectra and acceleration time history for the design earthquake is discussed in URS (2005c). The time history used in the analyses is shown in Figure D-4.

D-3.1 Analysis Method

The dynamic response of the dam was calculated using the finite element computer program QUAD4MB, which is an updated version of the programs QUAD4 (Idriss et al., 1973) and QUAD4M (Hudson et al., 1994). The version of QUAD4MB with the 2003 correction to the calculation of average acceleration of the sliding block was used. It calculates the average induced acceleration within a selected block of elements representing a potential sliding mass. This program performs a two-dimensional plane strain analysis using the equivalent linear method to estimate the non-linear response of soils.

D-3.2 Finite Element Model

A two-dimensional finite element model representing the maximum section was generated. The model contains 1127 elements and 1208 nodal points as shown in Figure D-5. The finite-element model incorporates the main material zones within the embankment and uses a compliant base to model the underlying foundation as a half-space.

D-3.3 Dynamic Material Properties

The material properties needed for the dynamic analysis are the unit weight, shear modulus, Poisson's ratio, and material damping. The unit weight is based on laboratory tests on soil samples retrieved from the site as discussed in the Geotechnical Data Report (URS, 2005a). The shear modulus and damping vary with the shear strain. In the QUAD4MB program, the soil is modeled as an equivalent-linear visco-elastic material with shear modulus and damping consistent with the shear strain. The variation of shear modulus and damping ratio with shear strain for different zones within the embankment was modeled using the sand curves developed by Seed and Idriss (1970) and clay curves developed by Vucetic and Dobry (1991). The modulus and damping relationships for the Temblor Sandstone were selected based on the effective overburden pressure and were developed based on relationships proposed by Seed and Idriss (1970) for sands and the effects of overburden pressure presented by EPRI (1993). A summary of material properties used in the dynamic response analyses of the embankment is presented in Table D-4. The modulus reduction and damping curves are shown in Figure D-6.

The low strain modulus was calculated using the equation proposed by Seed and Idriss (1970):

$$G_{max} = 1000\ K_{2max}\ (\sigma_m')^{0.5}$$

where: G_{max} = low strain shear modulus in psf

K_{2max} = a parameter dependent upon the relative density of the material, grain size, and other factors

The mean effective confining pressure, σ_m', was computed using the following equation:

$$\sigma_m' = \frac{1+2K_0}{3}\sigma_v'$$

where: σ_v' = the effective vertical pressure in psf

K_0 = the coefficient of earth pressure at rest (a K_0 of 0.4 was used)

The values of K_{2max} selected for the dam materials are 100, 60, and 80 for the Temblor sandstone, clay core, and chimney and blanket filter/drain, respectively. These values for K_{2max} were selected based on available test data and experience with similar soils at Los Vaqueros Dam and other dams (Mejia et al., 1991; Boulanger, et al., 1995). The dynamic behavior of the embankment will be controlled primarily by the response of the shells, and to a lesser degree, by the core. The chimney and blanket filter/drain were included in the model for completeness, but are not expected to influence the dynamic response of the dam. A shear wave velocity of 4,000 feet per second was selected to represent the half space below the base of the finite element model.

D-3.4 Dynamic Response Results

The results of the dynamic response analyses show that the peak accelerations increase from 1.07g at the base to around 1.3g at the embankment crest. Figures D-7 through D-11 show computed acceleration time histories at various points within the dam (see Figure D-5 for locations).

D-3.5 Earthquake-Induced Embankment Deformation

Permanent embankment deformations were evaluated using the procedure recommended by Newmark (1965) in which a potential sliding mass is modeled as a rigid block. When the earthquake-induced acceleration of the block exceeds the resistance along the sliding surface, permanent displacements are accumulated. In the analysis, the average horizontal acceleration time history associated with a potential sliding mass is obtained directly from the QUAD4MB output.

The permanent seismic displacement of the potential sliding block is calculated by double-integration of the difference between the average acceleration time history of the block and the yield acceleration of the block. Displacements were calculated assuming a reversal in motion polarity (i.e., sign reversed) to check for maximum displacement.

D-3.6 Calculated Displacements

The average horizontal acceleration time histories for the potential sliding masses defined in the pseudo-static analysis and the corresponding calculated permanent displacement time histories are shown graphically in Figures D-12a through D-12c and D-13a through D-13c for the upstream and downstream slopes, respectively. The calculated displacements correspond to horizontal translation of the center of mass of each sliding block. A horizontal displacement of 1.8 feet is calculated for upstream slide mass No. 3. Horizontal displacement of 0.6 feet is calculated for downstream slide mass No. 3. Horizontal displacements of less than about 0.6-foot were calculated for other upstream and downstream slide masses.

D-4 CONCLUSIONS REGARDING EARTHQUAKE-INDUCED DISPLACEMENTS

Horizontal displacements of up to about 1¾ feet were calculated from the Newmark analyses for upstream slide mass No. 3. The analyses show that the dam will remain stable after the MCE. Horizontal displacements of up to about 0.6-feet were calculated for downstream slide mass No. 3. These displacements are judged to be acceptable for a 210-foot high dam with a 22-foot freeboard.

Table D-4
Dynamic Soil Properties

Material	Unit Weight pcf		K_{2max}	Poisson's Ratio	G/Gmax Relationships	Damping Relationships
	Moist	Saturated				
Clay Core (Zone 1)	128	130	60	0.48	PI= 15%, Vucetic and Dobry, 1991	PI= 15%, Vucetic and Dobry, 1991
Filter/Drain (Zone 2/3)	125	130	80	0.35	Sand (median) Seed and Idriss, 1970	Sand (lower bound), Seed and Idriss, 1970
Earthfill Shell (Temblor Sandstone) (Zone 4)	130	135	100	0.45 (saturated) 0.35 (unsaturated)	Sand curves from Seed and Idriss (1970) modified for pressure dependency based on EPRI (1993)	Sand curves from Seed and Idriss (1970) modified for pressure dependency based on EPRI (1993)
Foundation - mélange	-	150	Vs = 4,000 fps Vp =8,000 fps	0.30	Rock, Schnabel, 1972	Rock, Schnabel, 1972

REFERENCES

Boulanger, Ross W., Bray J.D., Merry S.M., Mejia L.H. (1995). Three Dimensional Dynamic Response Analyses of Cogswell Dam, Canadian Geotechnical Journal 32: pp 452 - 464.

Duncan, J.M., and Wright S.F., and Wong K.S. (1990). Slope Stability during Rapid Drawdown, H.B. Seed Memorial Symposium, May, pp 253-272.

EPRI (1993). Method and Guidelines for Determining Design Basis Ground Motions, Electrical Power Research Institute, Palo Alto, California, Vol. 1, November.

Goodman, Richard, E., Ahlgren, Charles, S. (2000). Evaluating Safety of Concrete Gravity Dam on Weak Rock, Scott Dam, Journal of Geotechnical and Geoenvironmental Engineering, Volume 126, No.5, May.

Hudson, M., Idriss, I.M., Beikae, M. (1994). QUAD4M: A computer program to evaluate the seismic response of soil structures using finite element procedures and incorporating a compliant base: Center for Geotechnical Modeling, University of California, Davis.

Idriss, I. M., Lysmer, J., Hwang, R., and Seed, H. B. (1973). QUAD-4, A computer program for evaluating the seismic response of soil structures by variable damping finite elements: Earthquake Engineering Research Center, Report No. EERC 73-16, University of California, Berkeley, August.

Lowe III, John and Karafiath, L. (1960). Stability of Earth Dams Upon Drawdown, Proc. 1st PanAm Conference on Soil Mechanics and Foundation Engineering, Mexico City, Vol. 2, pp. 537-552.

Mejia, Lelio H, Sykora D.W., Hynes M.E., Fung K., Koester J.P. (1991). Measured and Calculated Response of Rock-Fill Dam, Proceedings Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, March 11-15 St Louis, Missouri, Paper No. 7.21.

Newmark N.M. (1965). Effects of Earthquakes on Dams and Embankments, Geotechnique, Vol. 15, No. 2, June.

Olivia Chen Consultants (OCC) (2003). Report on the Seismic Stability of Calaveras Dam. Prepared for the San Francisco Public Utilities Commission, Utilities Engineering Bureau.

Seed, H.B. and Idriss, I.M.(1970). Soil Moduli in Damping Factors for Dynamic Response Analysis, Report No. EERC 70-10, University of California, Berkeley, December.

URS (2004a). Evaluation of Remedial Design Alternatives for Existing Dam (Task 9.1), Draft Technical Memorandum, Calaveras Dam Conceptual Engineering, July.

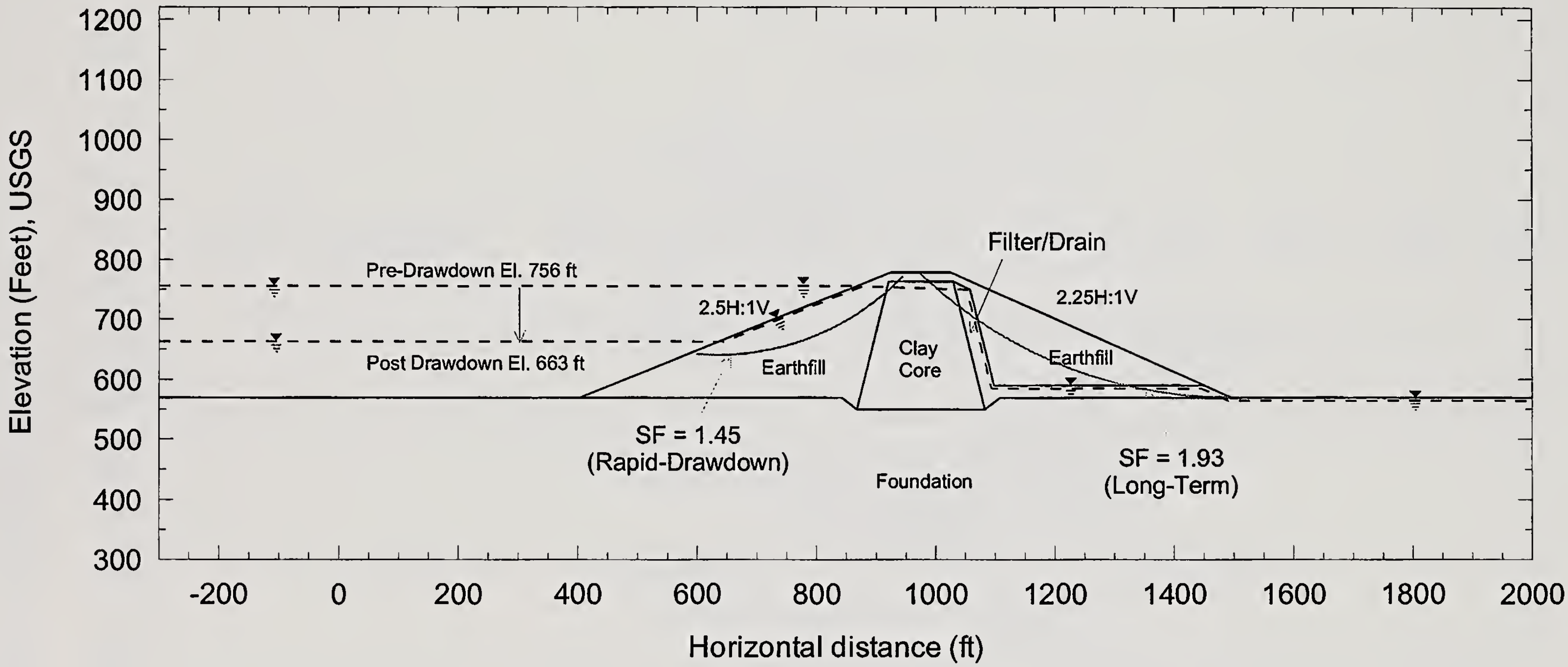
URS (2005a). Calaveras Dam Conceptual Engineering, Geotechnical Data Report, Final, January.

URS (2005b). Calaveras Dam Conceptual Engineering, Geotechnical Interpretive Report, Final, January.

URS (2005c). Seismic Source Characterization and Deterministic Ground Motion Assessment, Draft Technical Memorandum (Task 6.3), Final Technical Memorandum, Calaveras Dam Conceptual Engineering, February.

Vucetic, M. and Dobry, R. (1991). Effect of soil plasticity on cyclic response, Journal of Geotechnical Engineering, ASCE, Vol. 117, No.1.

Wright, S.G. (1991). UTEXAS3, A Computer Program for Slope Stability Calculations, Shinoak Software, May.


Elevation (Feet), USGS
1200
1100
1000
900
800
700
600
500
400
300
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Horizontal distance (ft)
Pre-Drawdown El. 756 ft
Post Drawdown El. 663 ft
2.5H:1V
Earthfill
Clay
Core
Filter/Drain
2.25H:1V
Earthfill
SF = 1.45
(Rapid-Drawdown)
Foundation
SF = 1.93
(Long-Term)

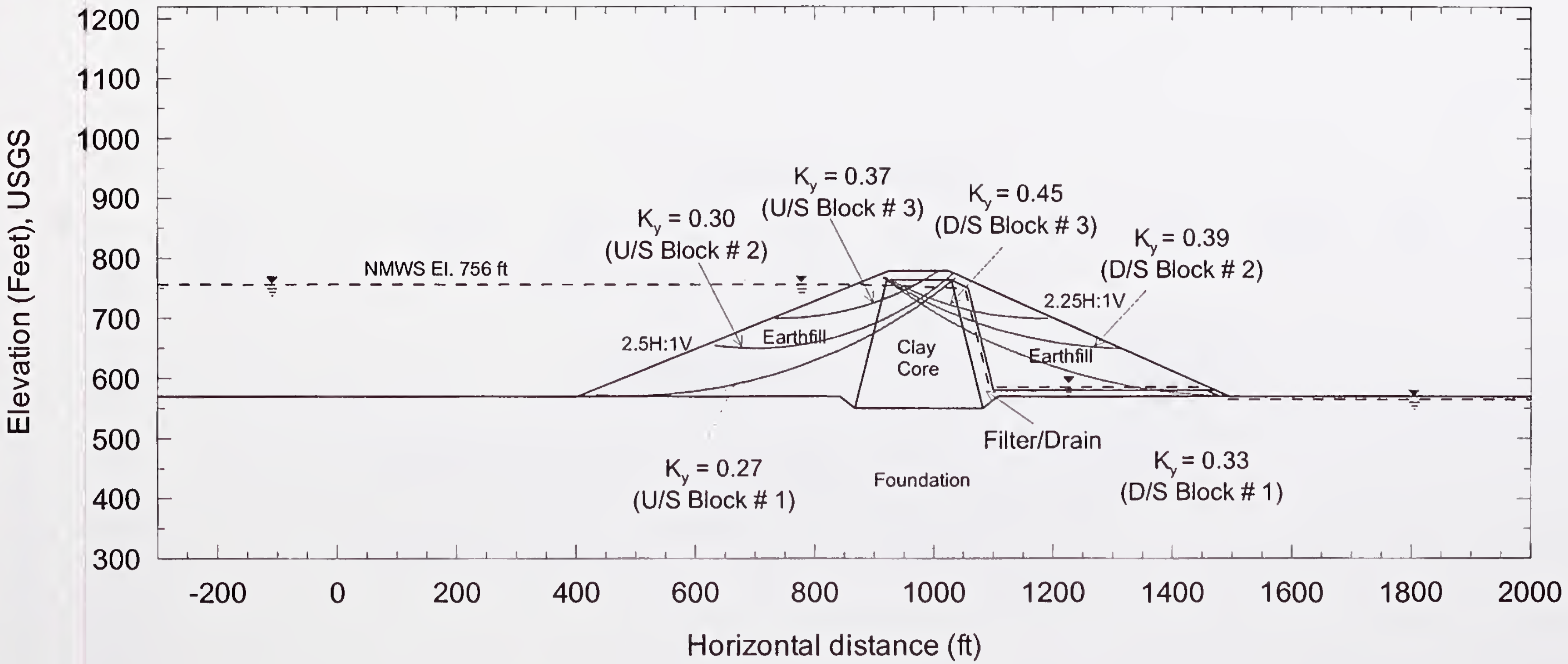
URS

Project No.26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

Replacement Dam
Long-Term and Emergency Rapid Drawdown
Analysis Results

Figure
D-1



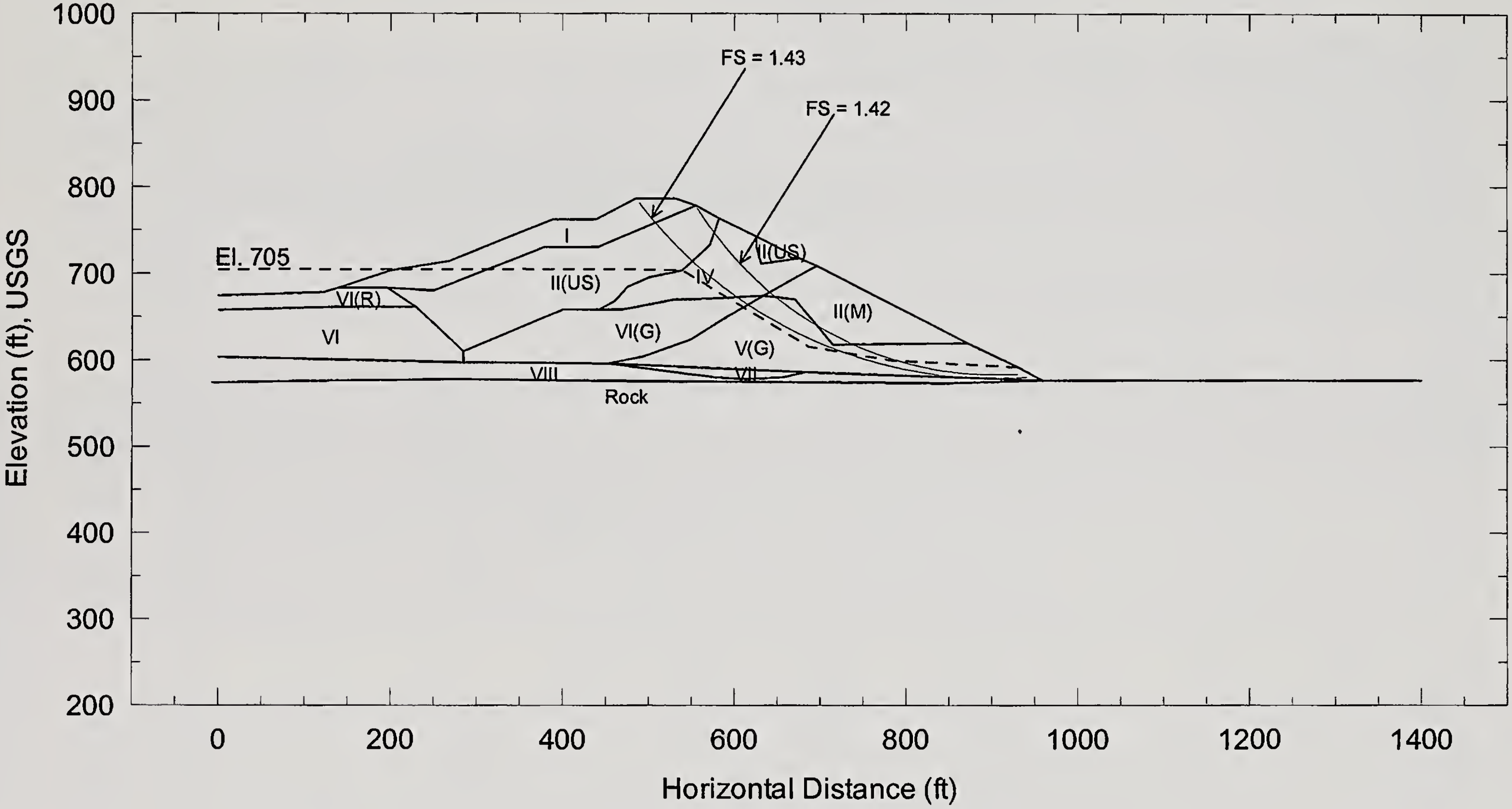
URS

Project No.26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

Replacement Dam
Pseudo - Static
Analysis Results

Figure
D-2

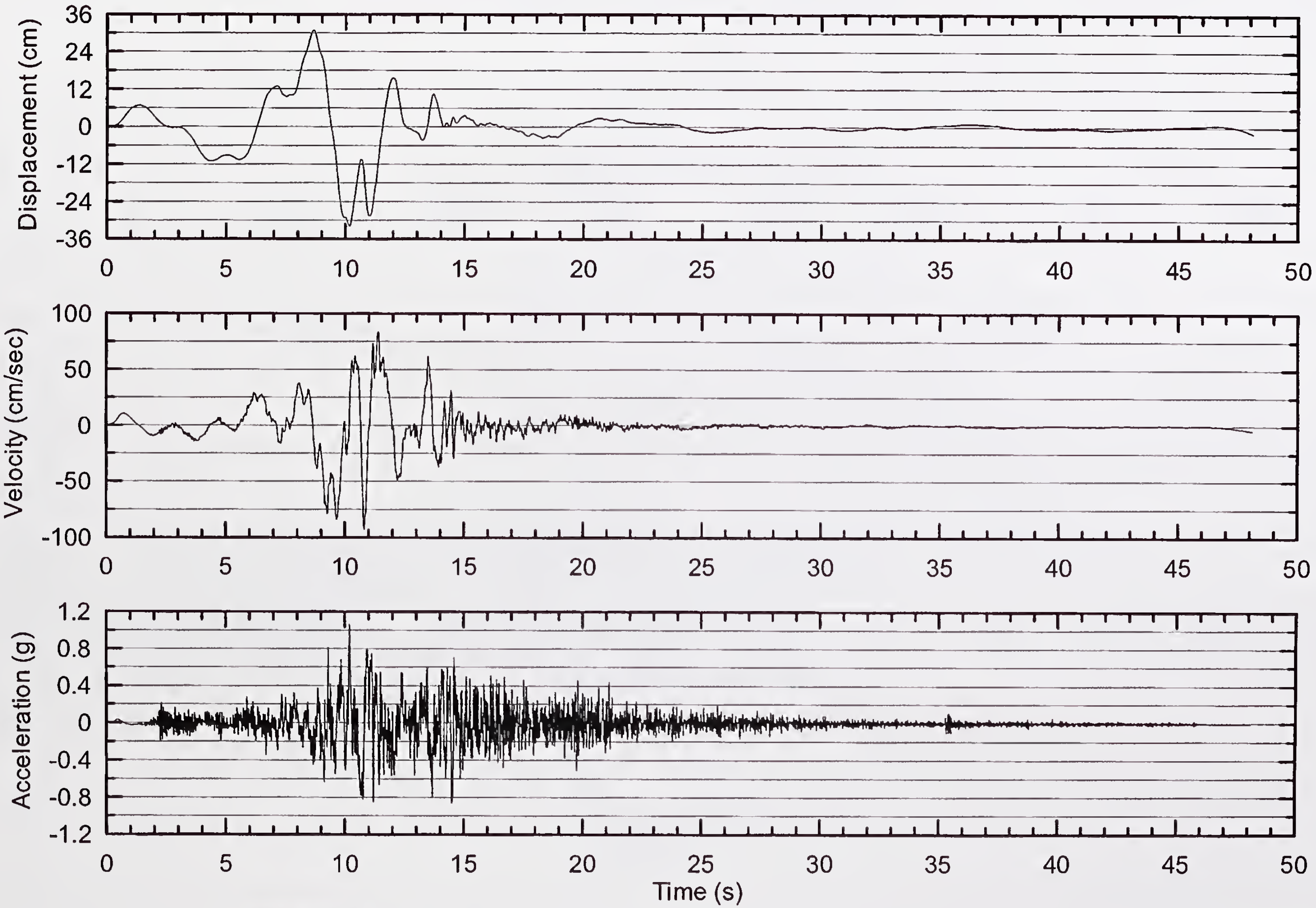


Note: Dewatering of Downstream Slope Required During Construction

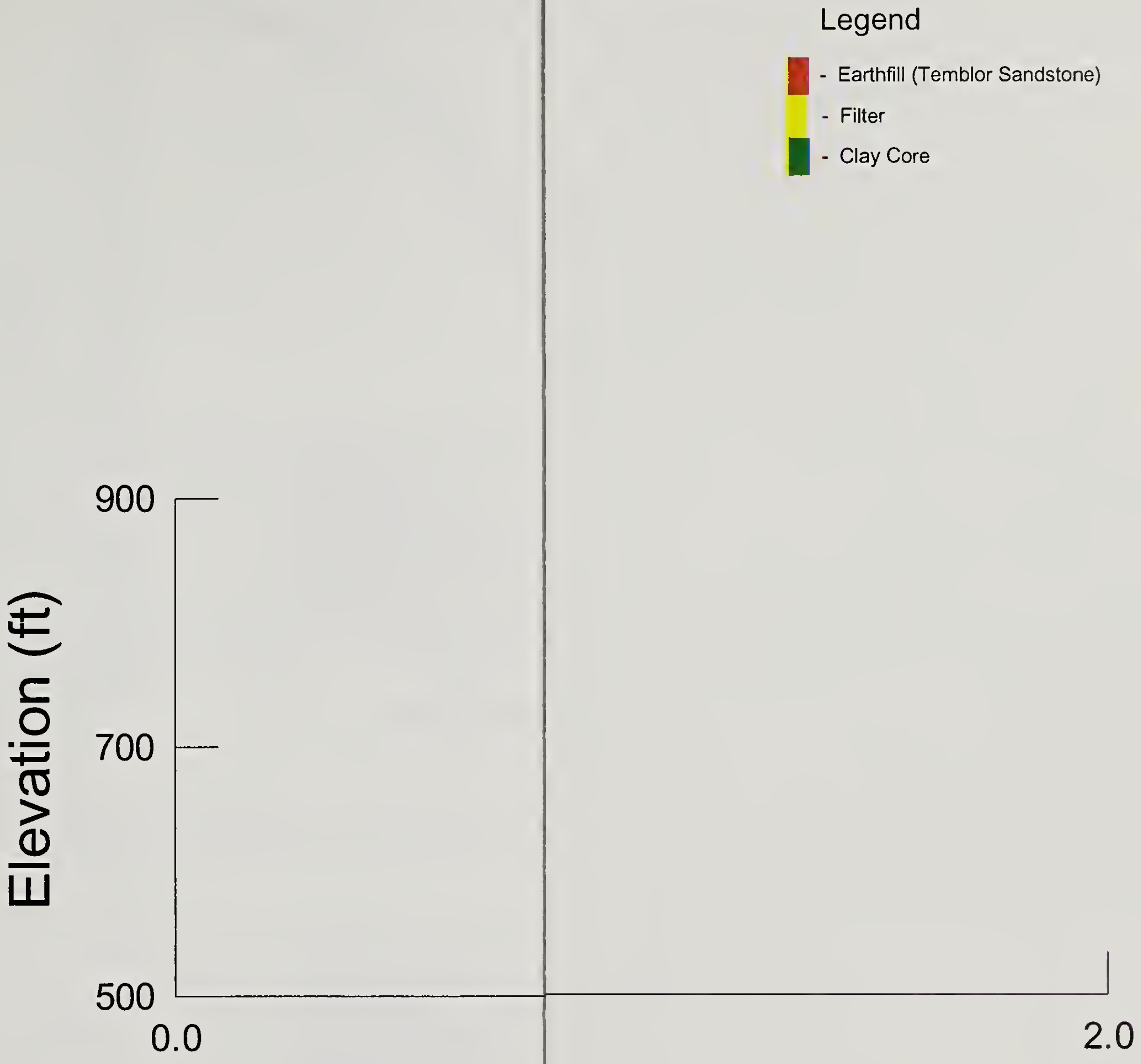
URS	Project No.26814817 SFPUC CALAVERAS DAM Agreement No. CS-716	COFFERDAM Stability Analysis Results	Figure D-3

X:\x_geo\Calaveras CER\Task 9.1\stability analysis\cut2005.grf

Design earthquake time history for Calaveras Dam, Horizontal Comp.

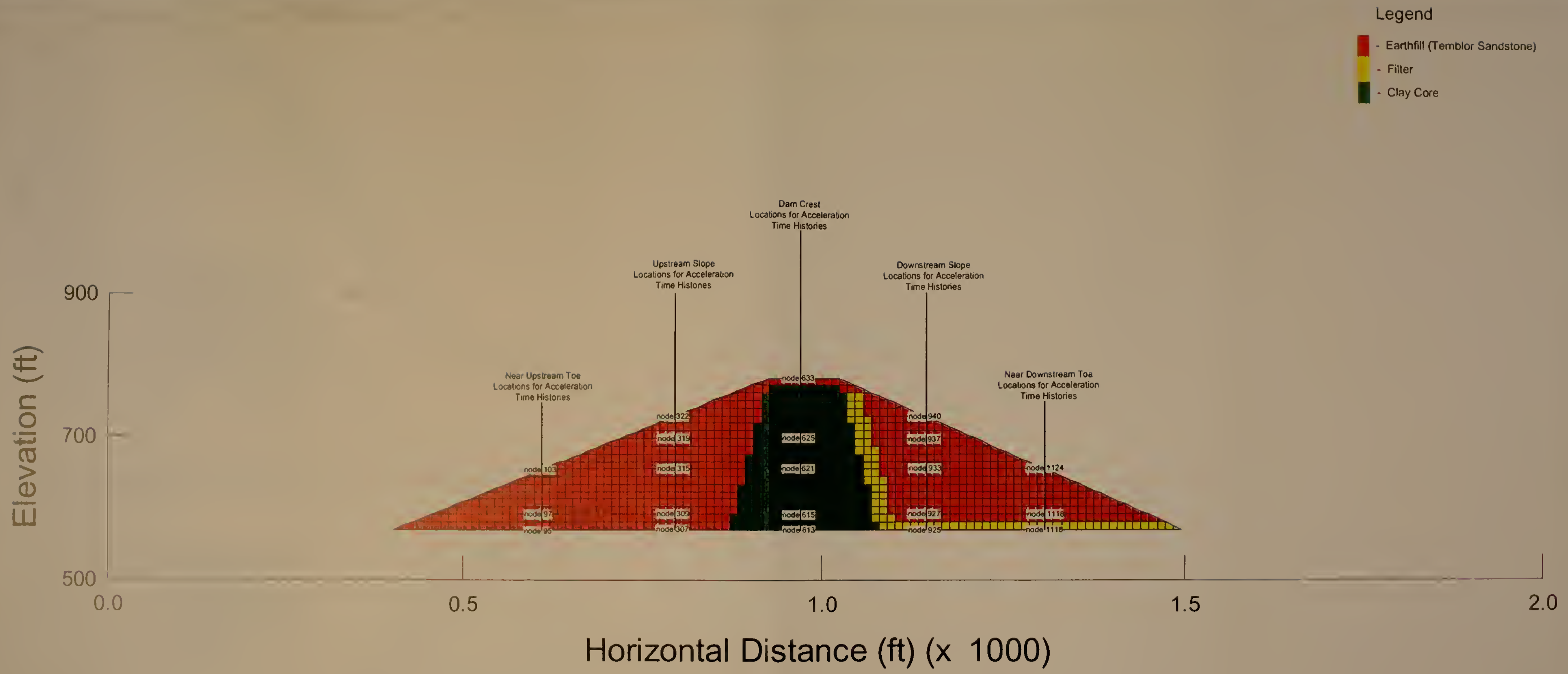


URS	Project No.26814817 SFPUC CALAVERAS DAM Agreement No. CS-716	Design Earthquake Horizontal Fault Parallel Time History	Figure D-4

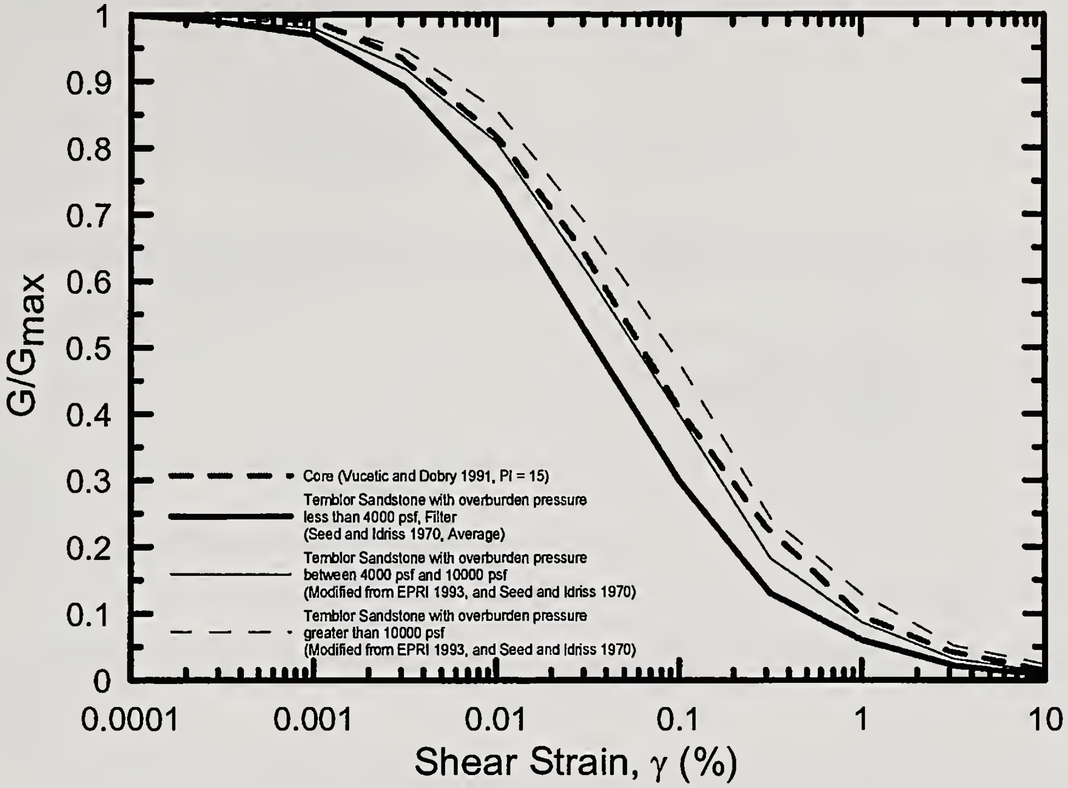


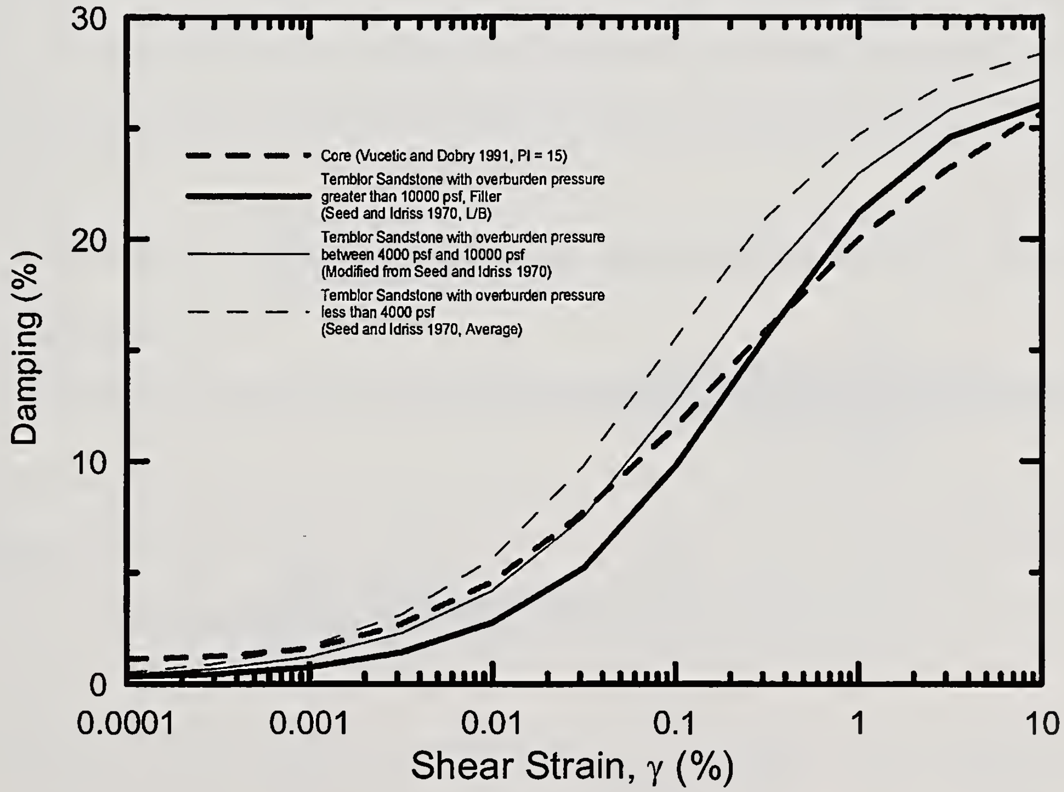
sional Finite Element Model
amic Response Analysis

Figure
D-5

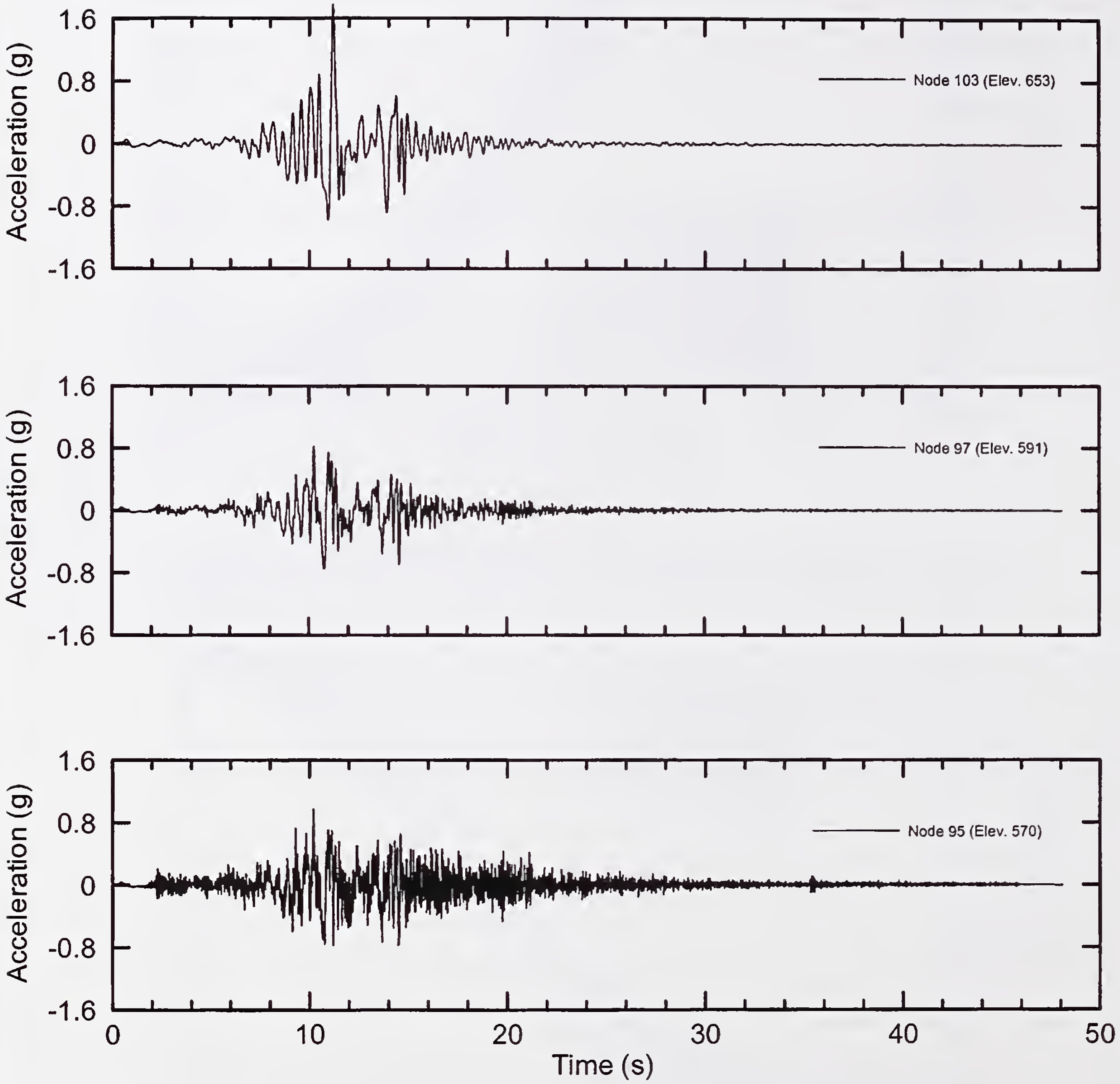

Legend
🟥 - Earthfill (Temblor Sandstone)
🟨 - Filter
🟩 - Clay Core
Dam Crest
Locations for Acceleration
Time Histories
Upstream Slope
Locations for Acceleration
Time Histories
Downstream Slope
Locations for Acceleration
Time Histories
Near Upstream Toe
Locations for Acceleration
Time Histories
Near Downstream Toe
Locations for Acceleration
Time Histories
node 633
node 322
node 319
node 315
node 309
node 307
node 103
node 97
node 95
node 625
node 621
node 615
node 613
node 940
node 937
node 933
node 927
node 925
node 1124
node 1118
node 1116
900
700
500
Elevation (ft)
0.0
0.5
1.0
1.5
2.0
Horizontal Distance (ft) (x 1000)

URS	Project No.26814817 SFPUC CALAVERAS DAM Agreement No. CS-716	Two Dimensional Finite Element Model for Dynamic Response Analysis	Figure D-5





URS	Project No.26814817 SFPUC CALAVERAS DAM Agreement No. CS-716	Modulus Reduction and Damping Curves Used for Dynamic Analysis	Figure D-6



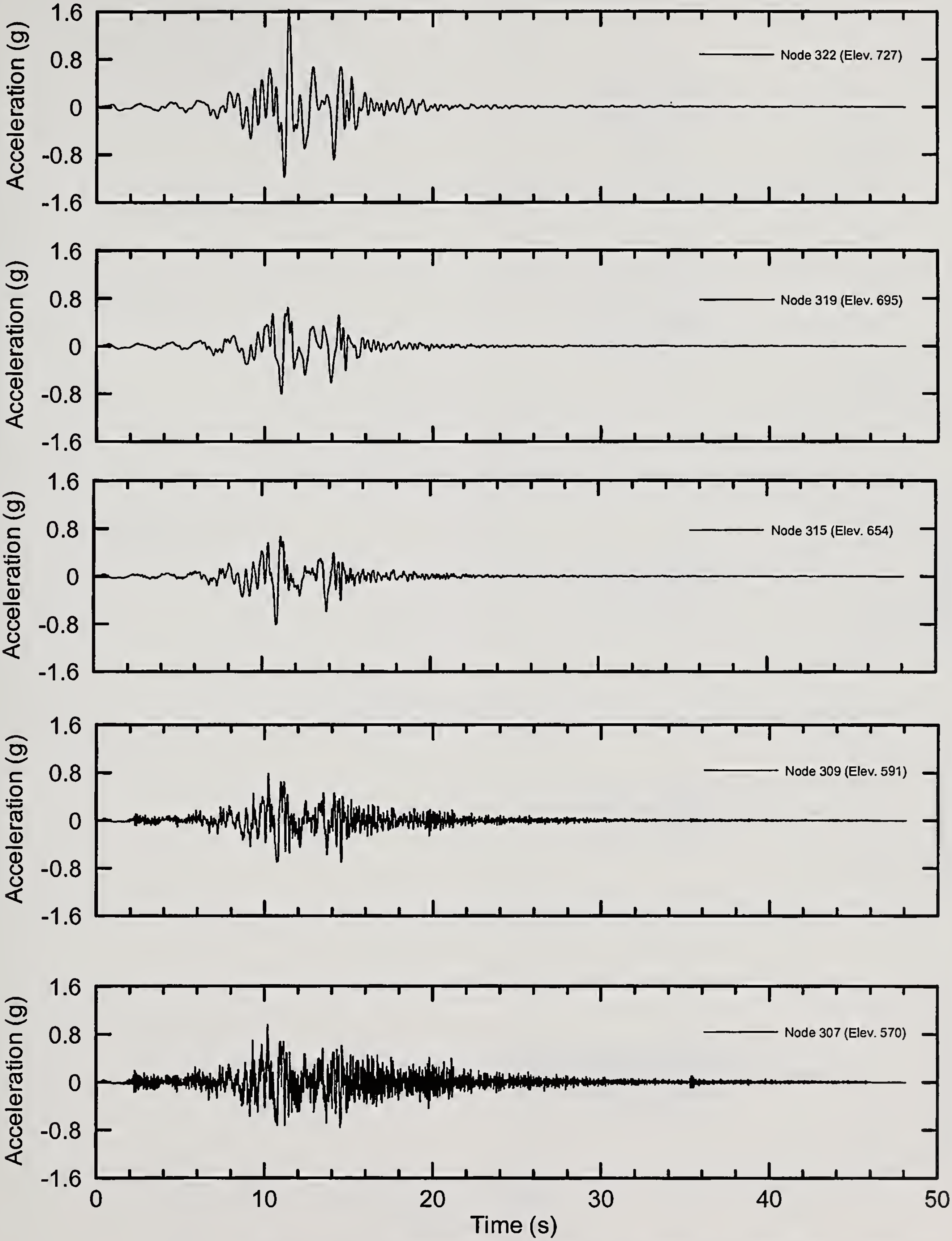
Project No.
26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

URS

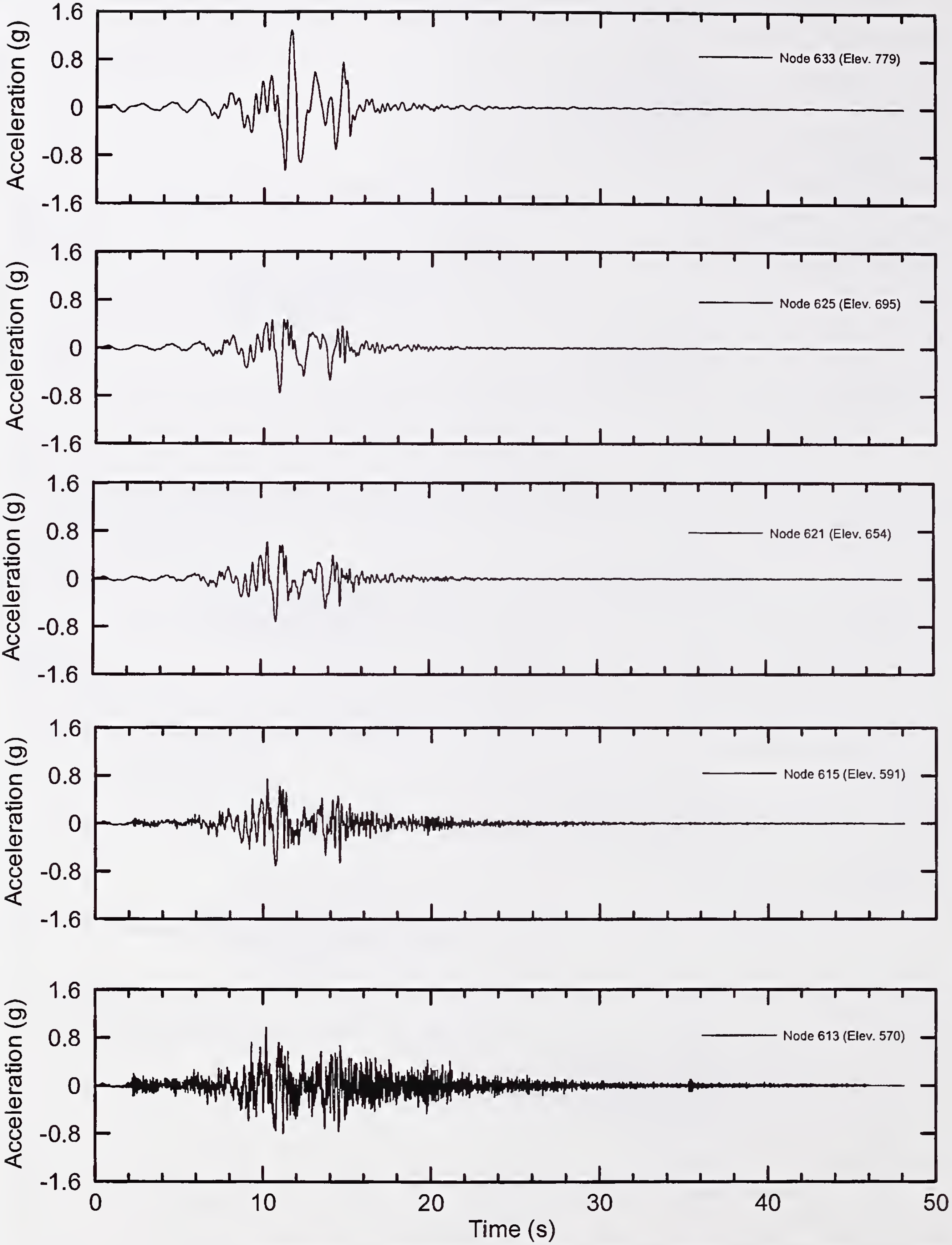
Horizontal Acceleration
Time Histories
Near Upstream Toe Locations

FIGURE
D-7



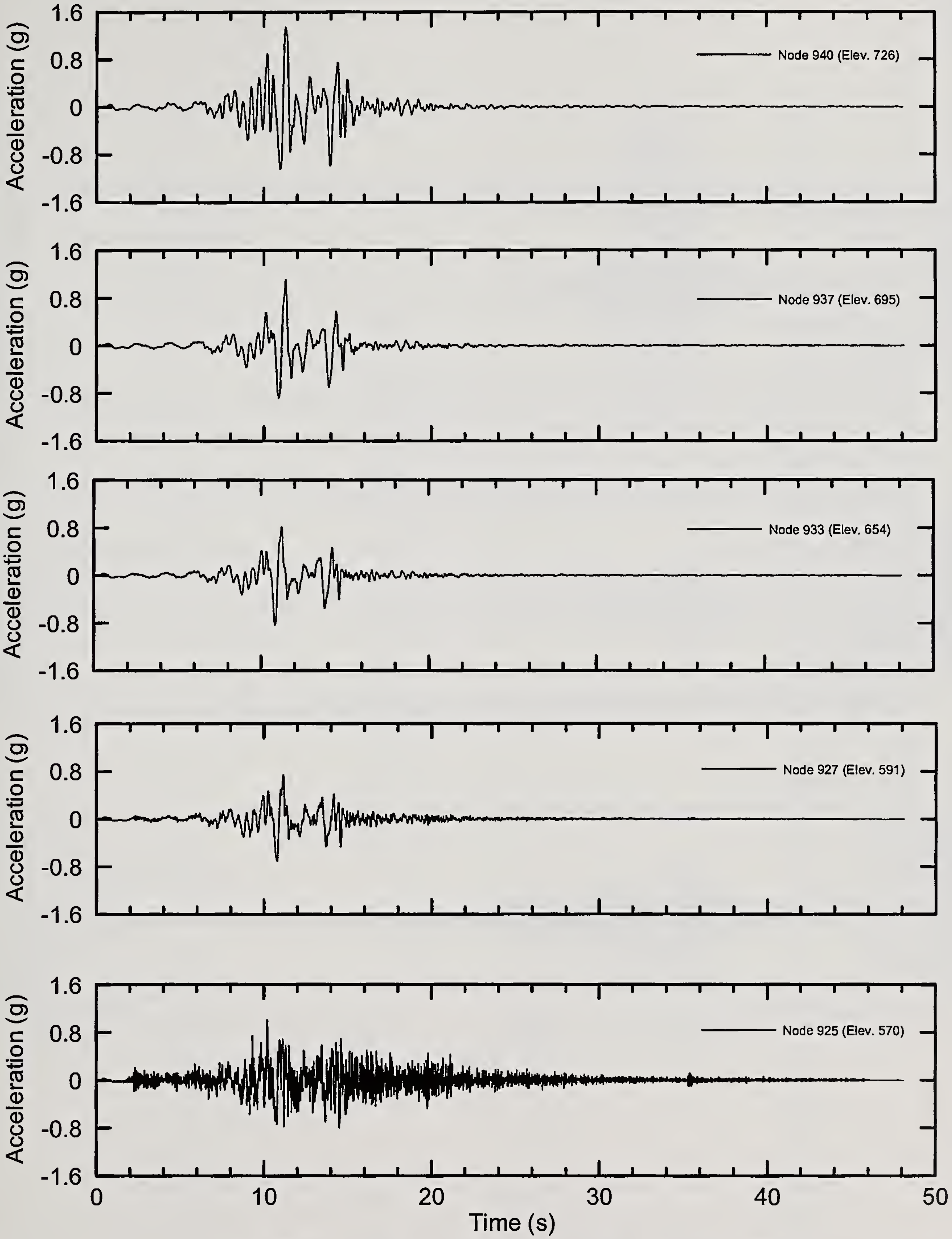
Project No. 26814817	SFPUC CALAVERAS DAM Agreement No. CS-716 URS	Horizontal Acceleration Time Histories Upstream Slope Locations	FIGURE D-8

X:\x_geo\Calaveras CER\—\P1US2.grf



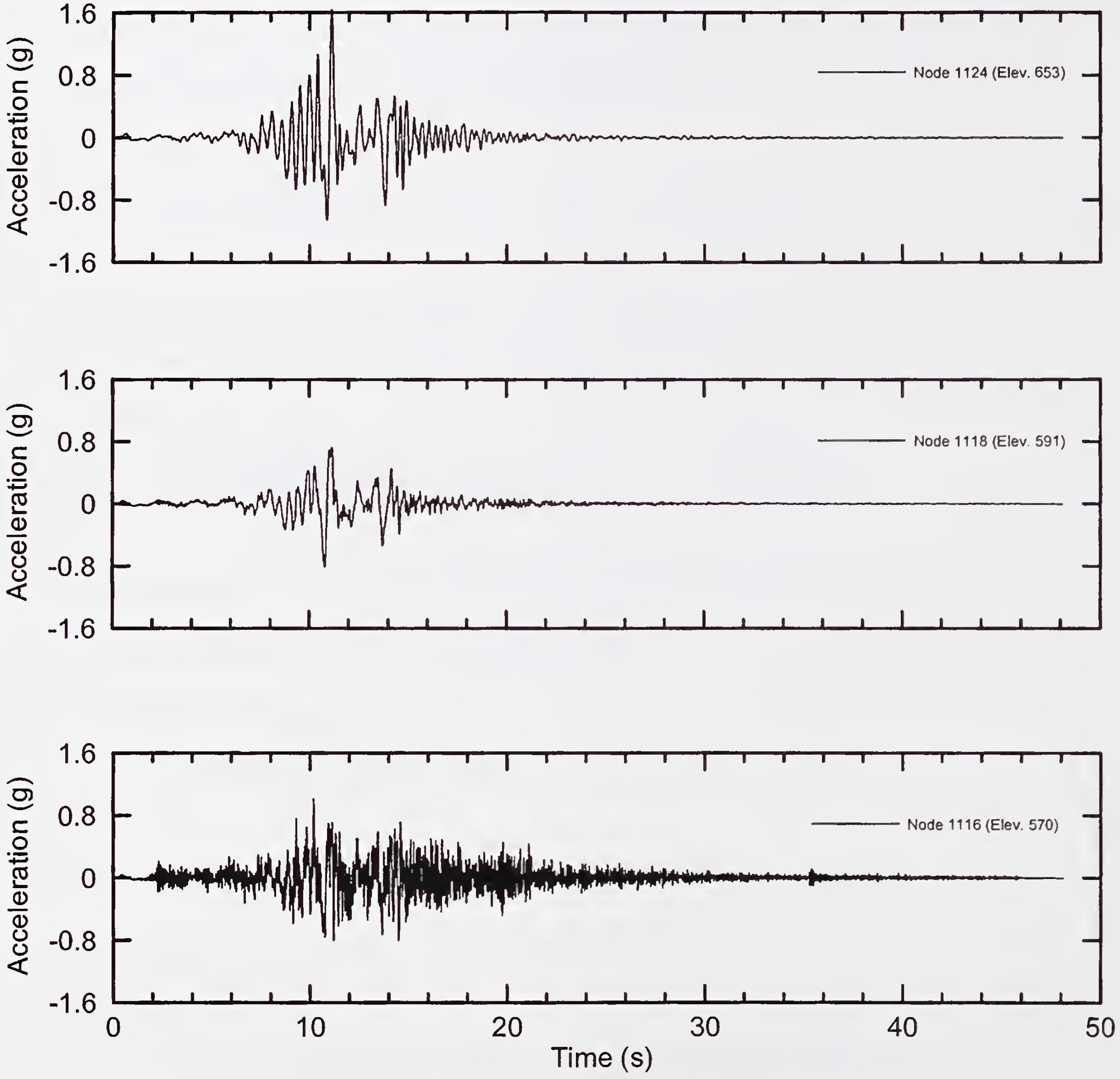
Project No. 26814817	SFPUC CALAVERAS DAM Agreement No. CS-716 URS	Horizontal Acceleration Time Histories Dam Crest Locations	FIGURE D-9

X:\x_geo\Calaveras CER\—\P1c.grf



Project No. 26814817	SFPUC CALAVERAS DAM Agreement No. CS-716 URS	Horizontal Acceleration Time Histories Downstream Slope Locations	FIGURE D-10

X:\x_geo\Calaveras CER\—\P10S1.grf



Project No.
26814817

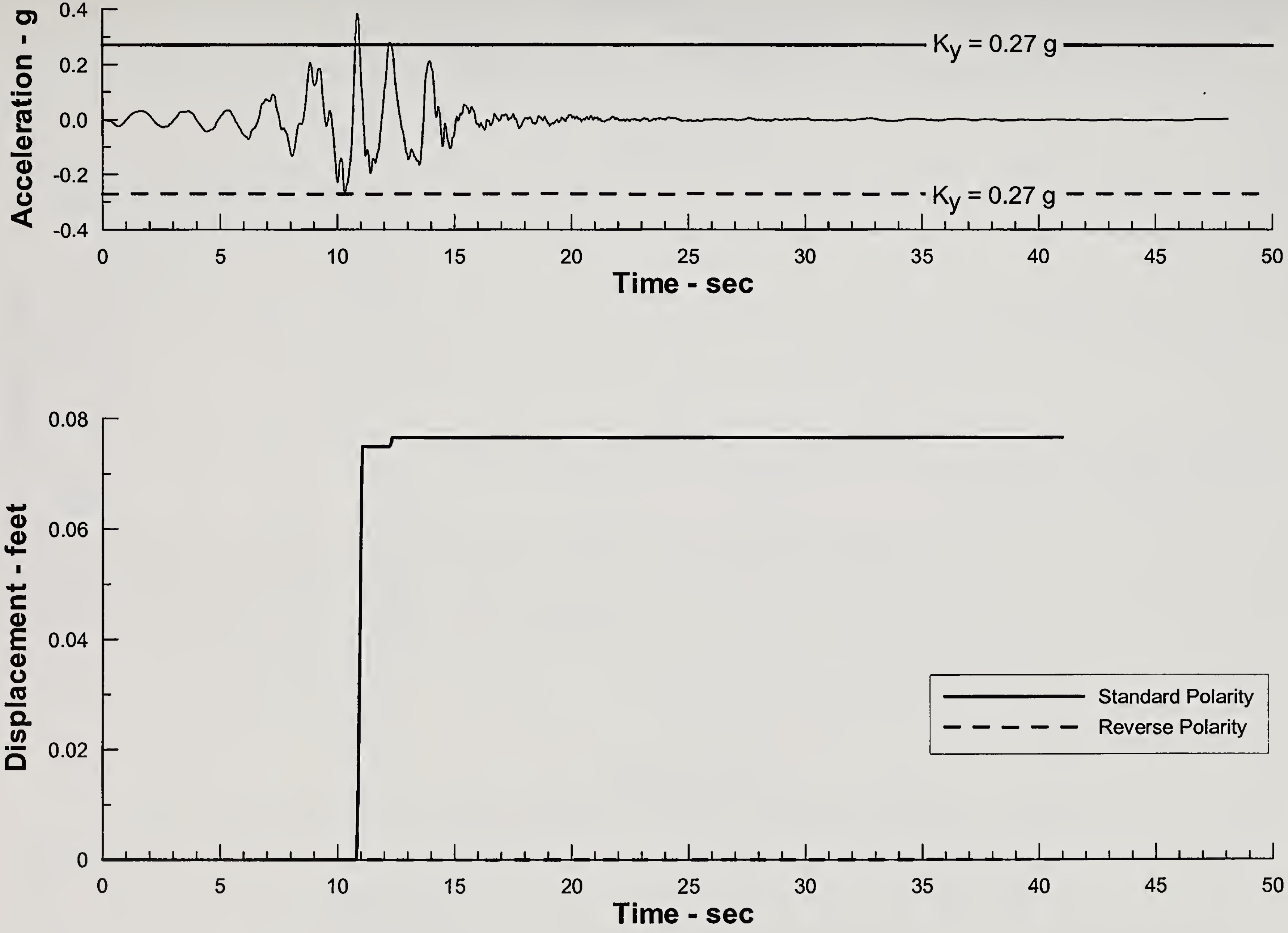
SFPUC
CALAVERAS DAM
Agreement No. CS-716

URS

Horizontal Acceleration
Time Histories
Near Downstream Toe Locations

FIGURE
D-11

X:\x_geo\Calaveras CER\—\P1DS2.grf



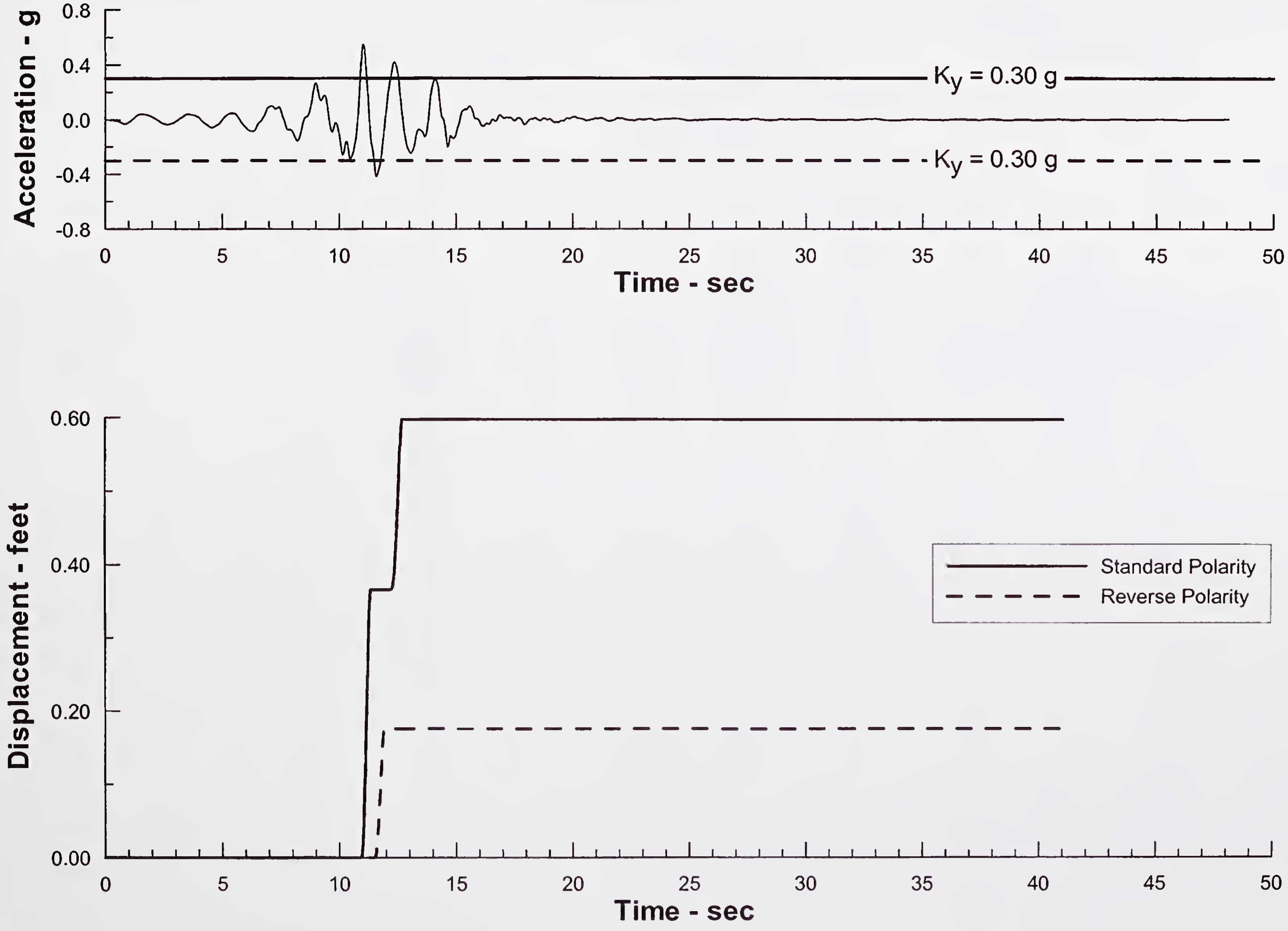
Project No.
26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

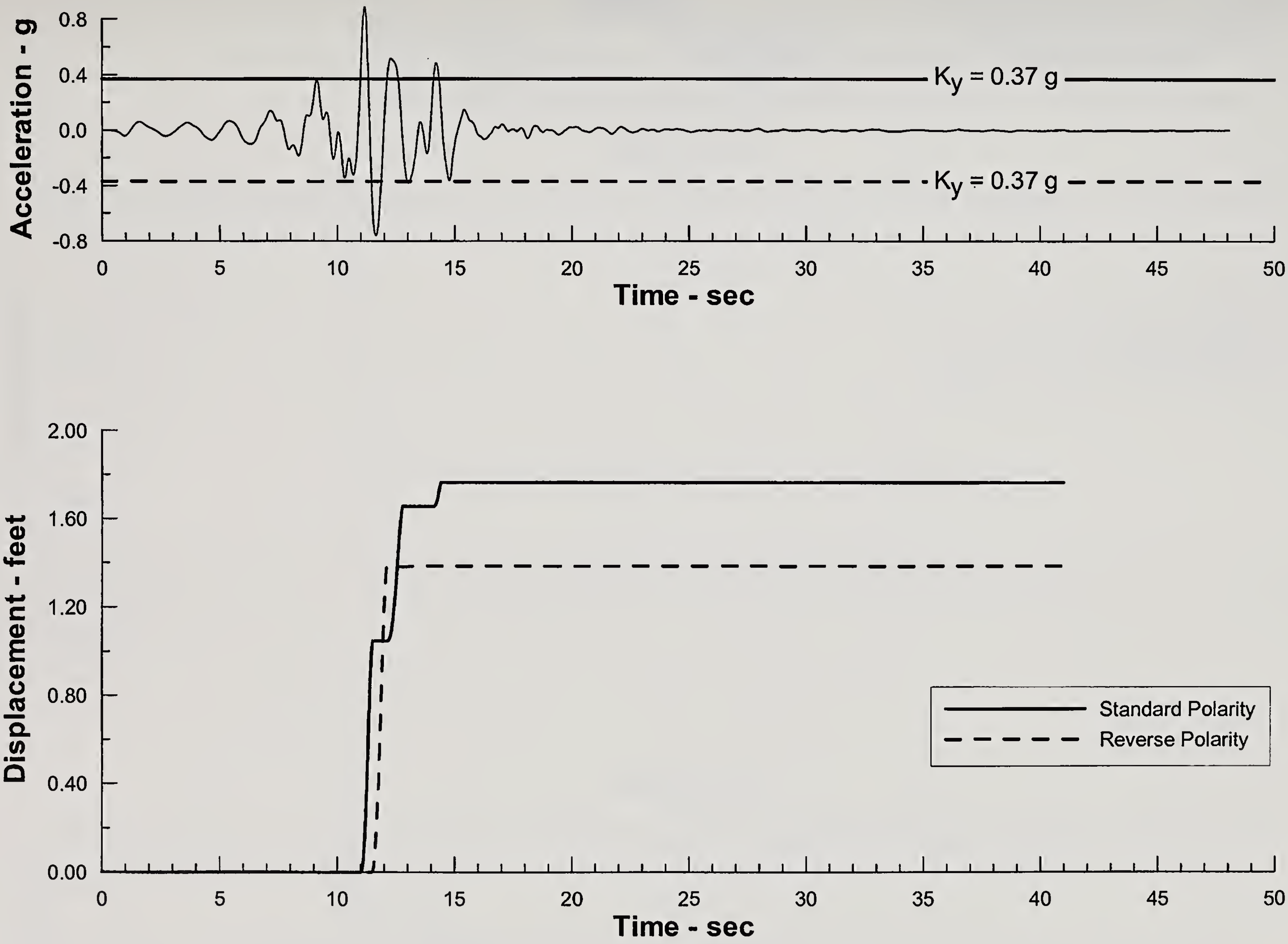
URS

Replacement Dam,
Average Horizontal Time Histories
for Critical Sliding Mass #1, Upstream

FIGURE
D-12a



Project No. 26814817	SFPUC CALAVERAS DAM Agreement No. CS-716	Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #2, Upstream	FIGURE D-12b
URS			



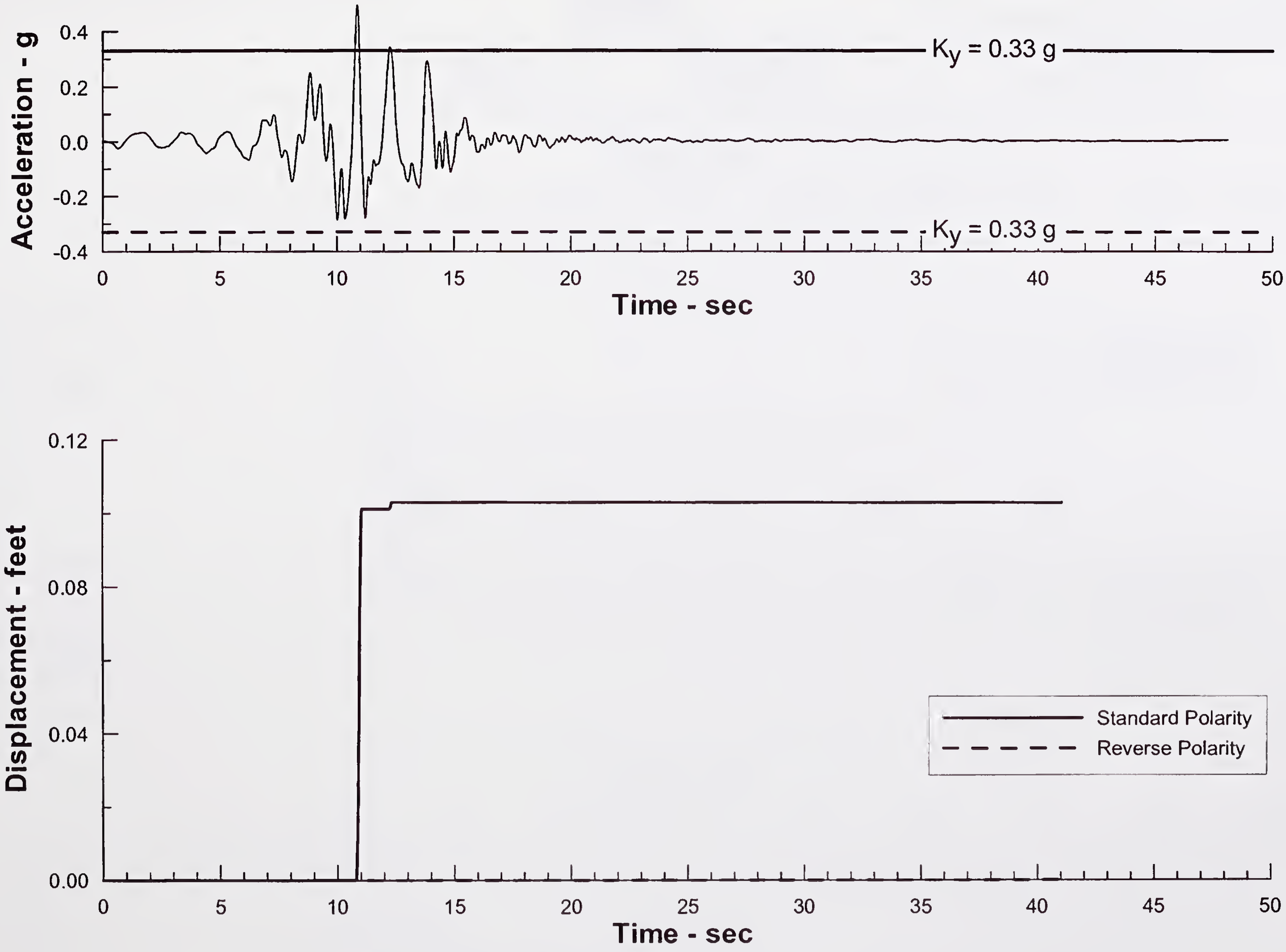
Project No.
26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

URS

Replacement Dam,
Average Horizontal Time Histories
for Critical Sliding Mass #3, Upstream

FIGURE
D-12c



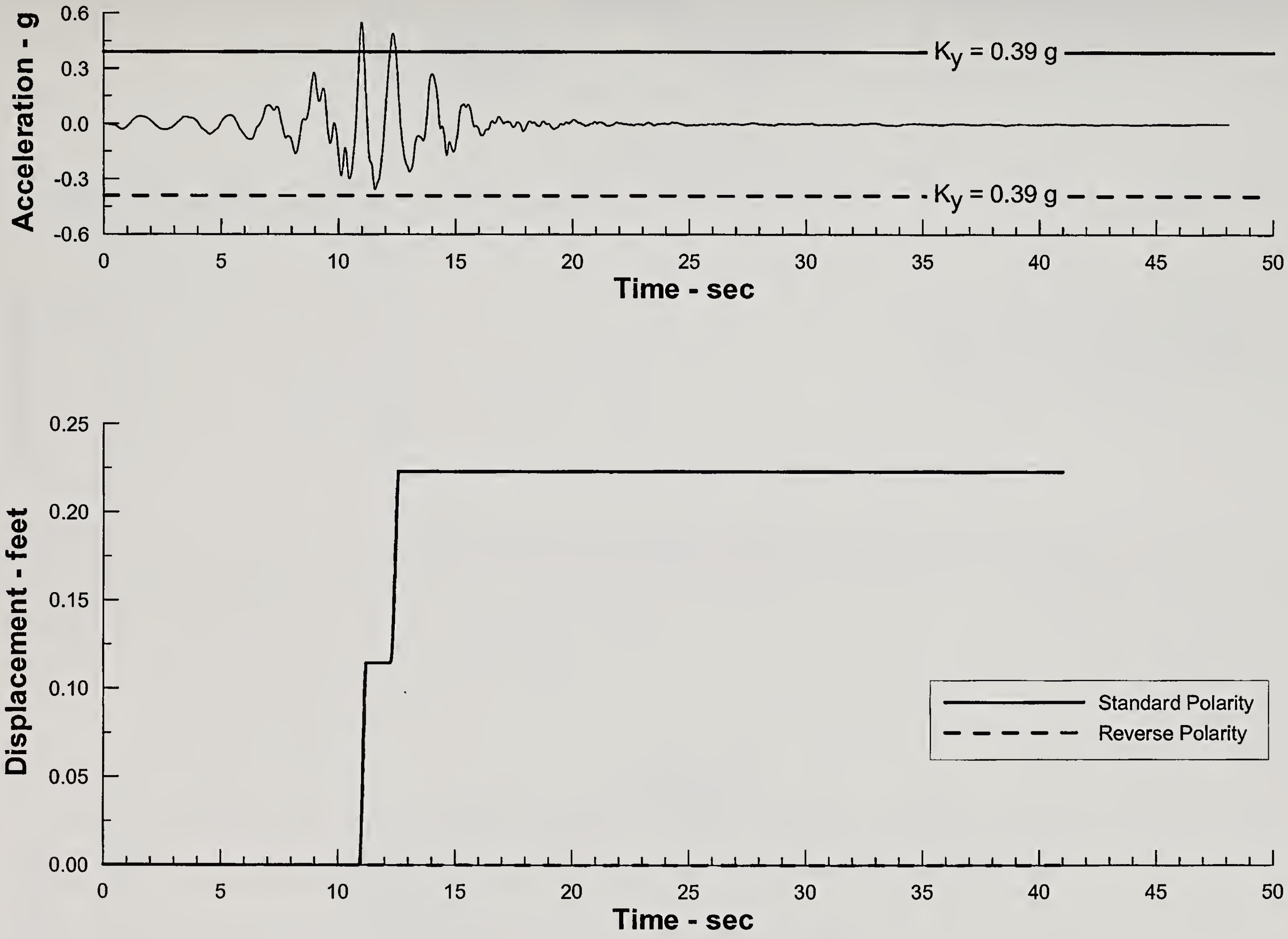
Project No.
26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

URS

Replacement Dam,
Average Horizontal Time Histories
for Critical Sliding Mass #1, Downstream

FIGURE
D-13a



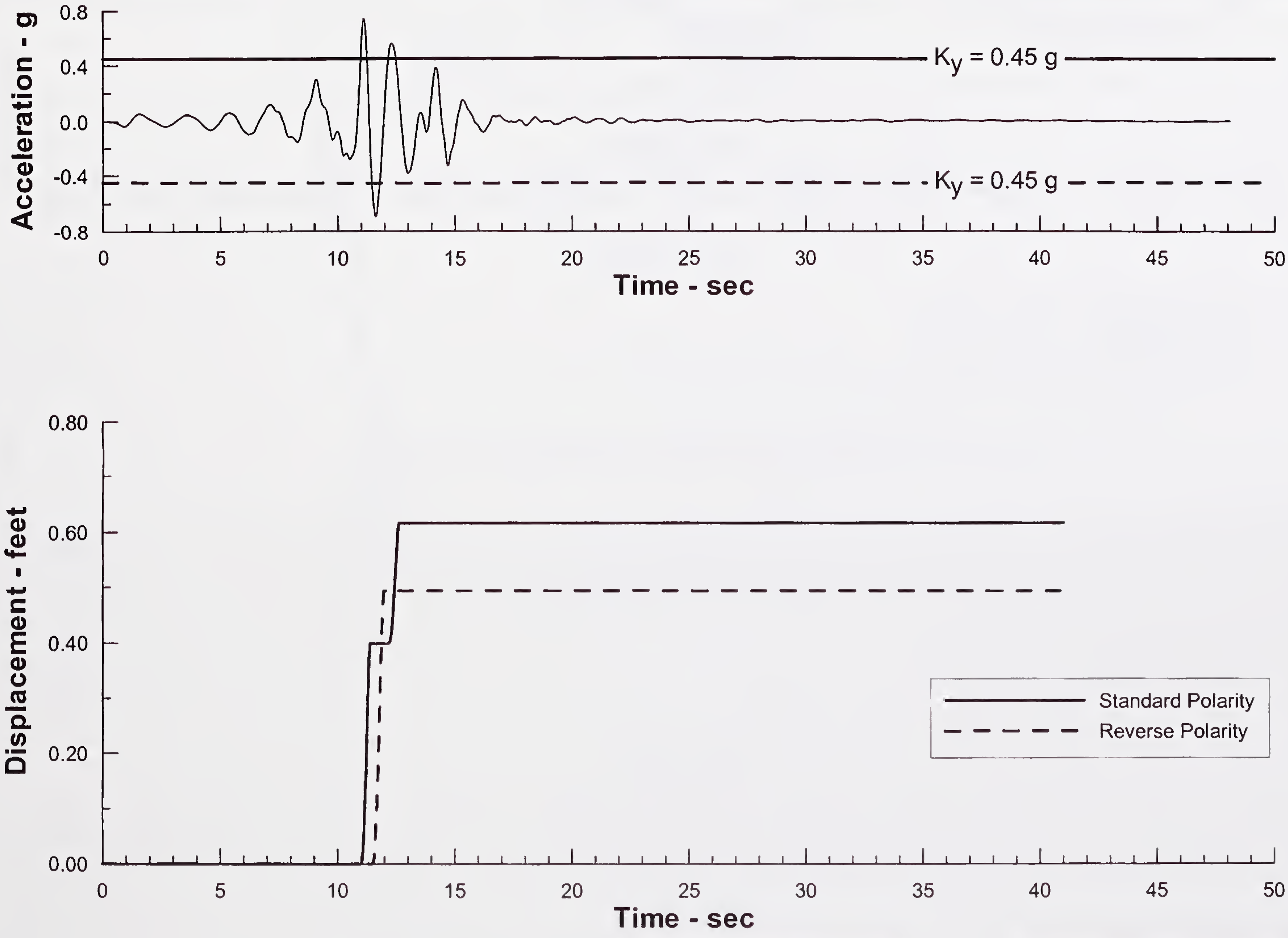
Project No.
26814817

SFPUC
CALAVERAS DAM
Agreement No. CS-716

URS

Replacement Dam,
Average Horizontal Time Histories
for Critical Sliding Mass #2, Downstream

FIGURE
D-13b



Project No. 26814817	SFPUC CALAVERAS DAM Agreement No. CS-716	Replacement Dam, Average Horizontal Time Histories for Critical Sliding Mass #3, Downstream	FIGURE D-13c
URS			

Appendix E

Outline Specifications

Technical specifications describing the scope, product requirements, and procedural requirements for each part of the project will be developed during final design. A table of contents for the technical specifications including the scope of each specification section was developed based on the conceptual design. The table of contents is shown in Table E-1. During final design, the table of contents will be updated.

The technical specifications follow the Construction Specifications Institute (CSI) format. Under the CSI format, specification sections are divided into three principal parts as follows:

- Part 1: General
- Part 2: Products
- Part 3: Execution

A technical specification outline, which shows the types of information that may be included within each of the principal parts, is included in this appendix.

Table E-1
Outline Specifications

Section Number	Name	Scope
DIVISION 0 - BIDDING AND CONTRACT REQUIREMENTS		
00700	General Conditions	The general conditions of the contract by which the work is conducted. Typically provided by the Owner. Includes definitions, preliminary matters, contract documents, availability of lands, subsurface and physical conditions, references, bonds and insurance, responsibilities of contractor, owner, and engineer, changes in the work, claims, payment, tests and inspections, suspension of work, termination, dispute resolution, liquidated damages, and other miscellaneous items.
00800	Supplementary Conditions	Amendments or supplements the General Conditions of the contract.
DIVISION 1 - GENERAL REQUIREMENTS		
01010	Summary of Work	Description of the work, milestone requirements, existing site conditions and restrictions, Owner's use of site.
01040	Project Superintendence and Coordination	Contractor's superintendence, coordination between Owner, Engineer, and Contractor, coordination with utilities, inspections by regulators.
01050	Construction Surveying	Survey requirements for layout of work and quantities.
01060	Safety, Health, Environmental and Regulatory Requirements	Health and Safety plan, environmental and other permit requirements, Storm Water Prevention Pollution Plan, and dust abatement.
01065	Preservation of Scientific, Historical, Archaeological, Prehistorical, and Paleontological Data	Notification and protection requirements.
01090	Reference Standards	Reference standards required for the work.
01200	Project Meetings	Pre-construction, partnering, and regular project and special project meetings.
01300	Submittals	Contractor submittals, submittal log, and Engineer and Contractor actions and responsibilities.
01311	Project Schedules and Reports (CPM)	Contractor's preliminary and project schedule requirements. Includes requirements for updating schedule, providing progress reports and look-ahead schedules.
01330	Measurement and Payment	All measurement and payment conditions including mobilization.
01400	Inspection of the Work	Engineer inspections of the work and Contractor quality control responsibilities.
01500	Construction Facilities and Temporary Controls	Contractor's staging and work areas, site housekeeping, protection of new and existing improvements, and security.
01510	Temporary Utilities	Temporary utility provisions including potable and non-potable water, electricity, sanitary facilities, and fire protection.
01521	Temporary Work and Storage Areas	Development, maintenance, and removal of temporary work and staging areas.
01530	Temporary Fences	Temporary construction fencing provisions.
01540	Load Restrictions	Protection of existing or new underground facilities due to overloading from construction traffic.
01550	Access, Haul Roads, Parking, and Traffic Controls	Access and control of traffic, parking within the project site, and haul roads from Borrow Area E.
01590	Field Offices	Contractor supplied Engineer's field office including furniture, communications equipment, computers, copy machines, security systems, on-site laboratory, and field support structures and Contractor's field office.

Table E-1
Outline Specifications

01600	Materials and Equipment	Contractor supplied materials and equipment including anchorage requirements.
01610	Delivery, Storage, and Handling	Provisions for delivering, storing, and handling of materials and equipment either supplied by the Contractor or provided by the Owner.
01700	Contract Closeout	Contract closeout schedule and procedures.
01730	Operation and Maintenance Data	Submission and format of operation and maintenance manuals and the instruction of Owner's personnel in the use of equipment.
01740	Guarantee and Warranty	Guarantee and warranty requirements for the work.
DIVISION 2 - SITE WORK		
02050	Demolition	Demolition and disposal of existing spillway, existing utilities, portions of the existing outlet tower, and other items within the work area.
02075	Control and Disposal of Water	Control and disposal of surface water.
02080	Foundation Dewatering and Groundwater Level Control	Dewatering for excavations including design and monitoring and disposal of water requirements.
02090	Blasting	Blaster qualifications, controlled blast methods and procedures, limitations, warning systems, and safeguards.
02110	Clearing, Grubbing, and Stripping	Removal and disposal of vegetation and roots, and removal and stockpiling of topsoil from the work areas.
02200	Foundation Excavation and Treatment	Dam and spillway foundation excavation and shaping, foundation cleaning, foundation treatment including dental and backfill concrete, slush grout, and surface grout.
02225	Trench and Structure Excavation and Backfill	Excavation, trench and structure backfill material properties, foundation preparation, backfill procedures, and testing.
02226	Borrow Areas	Opening, developing, and restoring borrow areas. Includes moisture conditioning and requirements for processing riprap and riprap bedding.
02227	Embankment Construction	Requirements for each zone within the embankment including material properties, placement methods, moisture conditioning, compaction, and testing. This section also includes requirements for instrumentation trenching and dam toe drain and outfall pipe systems.
02230	Base Coarse for Gravels	Subgrade preparation, material properties, placement, compaction, protection, and testing of base coarse materials for permanent access
02266	Foundation Drilling and Grouting	Grouter qualifications, drilling equipment, grouting equipment, grout materials and mixes, and execution of grouting. Execution of grouting includes preparation for grouting, sequence of drilling and grouting, water pressure testing, mixing and injection of grout, verification hole drilling and testing, and quality and control testing during grouting.
02275	Concrete Cutoff	Cutoff wall constructor qualifications, drilling equipment, cement and aggregate properties, concrete mix design, test sections, installation methodology, measurement of verticality and overlap, testing, remedial measures, disposal of waste materials.
02280	Well and Test Boring Decommissioning	Governing regulations, grout material requirements, grout placement methods for decommissioning of borings within the project.
02290	Embankment Material Test Fills	Materials, preparation of area for test fill pad, placement and compaction methods, inspection and testing of Temblor Sandstone.
02388	Excavation Rock Reinforcement	Material, installation, and testing requirements for rock reinforcement for excavated spillway rock slopes.
02445	Erosion Control	Hydroseeding materials, seed mix and application methods for the control of erosion on embankment slopes.

Table E-1
Outline Specifications

02555	Asphalt Concrete Pavement	Asphalt concrete materials properties and placement requirements for permanent access roads.
02560	Access Road Related Items	Section includes railing, signs, and marking requirements for permanent access roads.
02616	Reinforced Concrete Pipe and Fittings	RCP pipe type, joint requirements, connection requirements. Used for embankment toe drain and outfall pipe systems.
02726	Manholes	Concrete manhole types and installation methods. Used for embankment toe drain and outfall pipe systems.
02830	Chain Link Fence and Gates	Permanent project fencing materials and installation methods.
DIVISION 3 - CONCRETE		
03100	Concrete Formwork	Concrete formwork classification, design, materials, installation methods including tolerances, surface preparation, beveled edges, and removal.
03210	Reinforcing Steel	Reinforcement steel materials, fabrication, and placement methods.
03250	Anchorage in Concrete	Product requirements for anchor bolts, adhesives, anchor rods, and expansion bolts and methods of installation and quality control.
03251	Expansion, Construction, and Contraction Joints	Materials and installation procedures for expansion, construction, and contraction joints in concrete structures.
03300	Cast-In-Place Concrete	Concrete materials requirements, design of concrete mixes, batching and mixing of concrete, transportation, placing, consolidation, patching, finishing, curing, and testing of concrete.
03360	Shotcrete	Material and equipment requirements, shotcrete mix design, surface preparation, grounding, mixing, placing, joints, curing, protection, and testing of shotcrete.
03600	Grout	Material, preparation, placement, and curing requirements for non-shrink grout and mortar.
DIVISION 5 - METALS		
05050	Welding	Welder qualifications, preparation, general welding requirements, structural and stainless steel requirements, field quality control and testing.
05500	Fabricated Miscellaneous Metalwork	Material, fabrication, installation, and finish requirements for miscellaneous metal work required for the project.
DIVISION 9 - FINISHES		
09900	Paint and Coatings	Materials and installation requirements for painting and coating of exposed metal surfaces.
DIVISION 11 - EQUIPMENT		
DIVISION 13 - SPECIAL CONSTRUCTION		
13300	Instrumentation	Inclinometer, piezometer, instrumentation cable, survey monument, strong motion accelerograph, seepage weir material requirements. Installation methods including drilling, trenching, calibrating, and monitoring. Includes training of Owner personnel.
13302	Automated Data Acquisition System	Network and remote monitoring station units, communications, alarms, software, enclosures, installation, maintenance, and training for Owner personnel.

Table E-1
Outline Specifications

DIVISION 15 - MECHANICAL		
15050	Steel Pipe	Materials, fabrication, welding, installation, hydrostatic testing, field inspection and tests for 72-inch diameter outlet pipe extension.
15055	Fixed Cone Valve	Requirements for salvage and reinstallation at the end of the 72-inch outlet pipe extension of existing 72-inch fixed cone valve.
DIVISION 16 - ELECTRICAL		
16010	Electrical - General Provisions	Requirements for electrical utilities work that would be required at the intake tower and other locations at the dam.
16050	Basic Electrical Materials and	
16060	Level/Flow Instrumentation	
16110	Raceways	
16120	Conductors	
16450	Grounding	
16480	Low Voltage Motor Control	
16470	Distribution and Lighting Panels	
16500	Lighting	
16975	Testing and Start-Up	

SECTION 00000
SPECIFICATION OUTLINE

PART 1 GENERAL

1.01 SUMMARY

- A. Scope
- B. Products Furnished but not Installed Under this Section
- C. Products Installed but not Furnished Under this Section
- D. Allowances
- E. Alternates/Alternatives

1.02 REFERENCES

1.03 DEFINITIONS

1.04 SYSTEM DESCRIPTION

- A. Design Requirements
- B. Performance Requirements

1.05 SUBMITTALS

- A. Product Data
- B. Shop Drawings
- C. Samples
- D. Quality Control Submittals
  - Design Data
  - Test Reports
  - Certificates
  - Manufacturer's Instructions
  - Manufacturer's Field Reports
- E. Contract Closeout Submittals
  - Project Record Documents
  - Operation and Maintenance Data
  - Warranty

1.06 QUALITY ASSURANCE

- A. Qualifications
- B. Regulatory Requirements
- C. Certifications
- D. Field Samples
- E. Mock-Ups
- F. Pre-Installation Conference

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Packing and Shipping
- B. Acceptance at Site
- C. Storage and Protection

1.08 PROJECT/SITE CONDITIONS

- A. Environmental Requirements
- B. Existing Conditions
- C. Field Measurements

1.09 SEQUENCING AND SCHEDULING

1.10 WARRANTY

- A. Special Warranty

1.11 MAINTENANCE

- A. Maintenance Service
- B. Extra Materials

PART 2 PRODUCTS

2.01 MATERIALS

2.02 MANUFACTURED UNITS

2.03 EQUIPMENT

2.04 COMPONENTS

2.05 ACCESSORIES

2.06 MIXES

2.07 FABRICATION

- A. Shop Assembly
- B. Shop/Factory/Finishes
- C. Tolerances

2.08 SOURCE QUALITY CONTROL

- A. Tests
- B. Inspections
- C. Verification of Performance

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of Conditions

3.02 PREPARATION

- A. Protection
- B. Surface Preparation

3.03 ERECTION

3.04 INSTALLATION

3.05 APPLICATION

A. Special Techniques
B. Interface with Other Products
C. Tolerances

3.06 FIELD QUALITY CONTROL

A. Tests
B. Inspection
C. Manufacturer's Field Service

3.07 ADJUSTING

3.08 CLEANING

3.09 DEMONSTRATION

3.10 PROTECTION

3.11 SCHEDULES

- END OF SECTION -

Appendix F

Construction Cost Estimate and Schedule

TABLE OF CONTENTS

Appendix F Construction Cost Estimate and Schedule F-1

F-1 Introduction F-1
- F-1.1 Purpose And Scope F-1
- F-1.2 Conceptual Engineering Design F-1
- F-1.3 Estimate Methodology F-1
- F-1.4 Work Breakdown Structure F-2
- F-1.5 Construction Schedule and Sequencing of Critical Path Operations F-2

F-2 Basis of Cost Estimate F-3
- F-2.1 Sources of Cost Data and Level of Detail F-3
- F-2.2 Construction Cost - Project Features F-4
- F-2.3 Escalation F-6
- F-2.4 Contingency F-7

F-3 References F-7

Tables

Table F-1 Construction Cost Estimate

Figures

Figure F-1 Conceptual Level Construction Schedule for Replacement Dam

Appendices

Appendix F-1 Cost Estimate Back-Up

F-1 INTRODUCTION

F-1.1 Purpose And Scope

This appendix presents the conceptual-level construction cost estimate prepared for the Calaveras Dam Replacement Project. The cost estimate is based on the work described in the Conceptual Engineering Report (CER) and the following Calaveras Dam Conceptual Engineering technical memoranda and reports:

- Spillway and Outlet Works (Task 7.0), Draft, July 2004 (URS, 2004a).
- Existing Dam Remediation Alternatives (Task 9.1), Draft, July 2004 (URS, 2004b).
- Evaluation of Replacement and Enlarged Dam Alternatives (Task 9.2), Draft, July 2004 (URS, 2004c).
- Operation of Reservoir/Storage and Bypass Requirements During Construction (Task 11.1), Draft, July 2004 (URS, 2004d).
- Geotechnical Data Report, Final, January 2005 (URS, 2005a).
- Geotechnical Interpretive Report, Final, January 2005 (URS, 2005b).
- Cost Estimate of Alternatives (Task 13), Final, March (URS, 2005c).
- Commercial Materials Source Assessment, (Task 5.3), Final, March 2005 (URS, 2005d).

F-1.2 Conceptual Engineering Design

The general site plan is shown on Figure 7-1 (in the CER text), which indicates the locations of the borrow areas, disposal areas, staging and stockpile areas, and potential haul roads. The plans, sections and details of the replacement dam and appurtenant structures are shown on Figures 7-2 to 7-8. Figure 7-9 presents the materials balance diagram.

F-1.3 Estimate Methodology

The construction cost estimate is a Class 4 estimate as described by the Association for the Advancement of Cost Engineering (AACE, 1998) as follows:

> *" Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, conceptual evaluation, and preliminary budget approval. Typically, engineering is from 1% to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists."*

The major features in the construction cost estimate, such as the dam embankment, are defined based on the design described in the CER. Costs for each of the features were estimated by developing unit costs and multiplying these by the calculated quantities. Unit costs for embankment materials obtained on-site were developed by estimating equipment crews (number and size of primary equipment, together with monthly ownership and operating costs) and production rates (cycle times and total yards per shift). These unit costs were compared with historical database unit prices. Vendor quotes were used, where possible, for embankment materials obtained off-site and for the major mechanical equipment. Where the level of design detail was insufficient to support an estimate, lump sum allowances based on historical experience for similar projects were used.

Estimated costs for project delivery that account for program and project management, pre-design planning, environmental planning and review, engineering design, construction management, and department and agency fees are not included in this appendix, but are indicated in Section 9 of the CER. Environmental mitigation costs are also indicated in Section 9.

F-1.4 Work Breakdown Structure

For the purpose of developing and presenting this conceptual-level construction cost estimate, the work was divided into the following five major elements for the dam and appurtenant works:

- General Requirements
- Site Preparation
- Dam Foundation
- Embankment
- Hydraulic Structures

Each of the above five work elements was subdivided along activity levels that can be identified, managed and controlled. The construction cost estimate is presented in Table F-1. The table presents the estimated cost for each activity under the five main elements of the work. The summation of all the activity costs along with a 30 percent design contingency is the estimated construction contract cost (Engineer's Class 4 Dam Construction Cost Estimate). An explanation of the costs covered by the design contingency is included in Section F-2.4.

Direct and indirect costs were estimated for each of the activity levels under the five major elements of the work as shown in Appendix F-1. The direct cost includes the quantity of work, the labor, equipment, material and other costs estimated for each item. The indirect cost includes general and administrative costs (G&A), profit, and bond costs. The direct and indirect costs were added together to arrive at total and unit costs. G&A covers home office overhead costs and typically falls within the range of 3 to 5 percent of the total direct construction cost. For this estimate, G&A costs comprise 5 percent of the total estimated direct construction cost. Profit and bond costs used are approximately 10 percent and 1 percent, respectively, of the total estimated direct construction cost. Costs for the contractor's project management, administration and quality control staffing are based on usual wages and salaries for the site area. Prevailing wage (Davis-Bacon) rates were used to estimate labor costs.

F-1.5 Construction Schedule and Sequencing of Critical Path Operations

A conceptual-level construction schedule was developed to assess the total estimated construction duration as shown on Figure F-1. The schedule shows the main construction activities for the dam and appurtenant works.

Duration estimates for the various construction operations were based on experience on other projects and, where applicable, on the estimates used to develop construction costs. Factors that would affect the actual duration of the project include the actual timing of Notice to Proceed (NTP) and the start of construction, adverse weather, the reservoir stage at the time of NTP, the ability to upgrade and restrict public access on Calaveras Road north of the site, and utilization of double shifts for excavations and earthmoving.

The schedule provides a description of the main elements of work assessed to constitute the critical path for construction together with major elements of the work that are not on the critical path. The schedule shows the interrelationship between work activities and can be used to assess construction logistics and to identify potential constraints on construction.

The durations for the major earthworks items were based on two ten-hour shifts per day with 5 days per work week. Saturday construction work would be contractor float used to mitigate construction slippage. Fill placement (and borrow) operations were restricted to a nine-month construction season (mid-March through mid-December) although foundation excavation operations would, with usual rain delay allowances, be permitted to proceed year round. Ancillary operations such as underground excavation, foundation grouting and cutoff wall construction, and concrete and mechanical work associated with the appurtenant facilities could occur over a 12-month construction period.

Construction duration through substantial completion would be about 2½ years. An NTP date early in the year would be expected to result in a shorter overall duration. An additional 25% duration should be added for planning purposes. Therefore, for planning purposes the duration of construction would be about 3 years.

F-2 BASIS OF COST ESTIMATE

F-2.1 Sources of Cost Data and Level of Detail

F-2.1.1 Construction Pricing Methodology

The major features in the construction cost estimate are based on the design presented in Section 7 in the CER text. Construction costs for these features were estimated by developing unit costs and multiplying these by the quantity measurement. Unit costs for embankment materials obtained on-site were developed by estimating equipment crews (number and size of primary equipment, together with monthly ownership and operating costs) and production rates (cycle times and total yards per shift). These unit costs developed were compared with historical database unit prices. Vendor quotes were used for embankment materials obtained off-site (URS, 2005d). Subcontractor costs were used for the concrete diaphragm/secant pile cutoff wall. Costs were based on the use of an on-site concrete batch plant.

Where the level of design detail was insufficient, lump sum allowances based on historical experience with similar structures were used. It is assumed that logic, methods and procedures for pricing are typical for the construction industry and that procurement will be achieved through an open and competitive bidding process utilizing industry standard specifications.

F-2.1.2 Quantities

The main earthworks quantities were computed from the conceptual design drawings (see Section 7 in the CER text) using the Autodesk Land Desktop 3 CADD program and independently checked using average end area methods. Allowances for secondary quantities were based on judgment. The quantities represent in-place volumes, either in-situ or in-bank, as appropriate. Quantities for hydraulic structures are based on conceptual layouts shown in the CER.

A material balance (or flow) diagram was prepared to show material quantities associated with the required excavations, borrow area excavations, and embankment construction (see Figure 7-9 in the CER text). The diagram indicates the potential range in the amount of waste material to be disposed of and the sources of these materials, where construction materials for the dam would be obtained, and the on-site reserve in the construction materials. Estimates for material bulking and shrink/swell along with amount of unacceptable construction material are indicated on the diagram and costs for these factors are incorporated into the unit prices estimated for the various items of the dam embankment. Overbuild allowances for material places in excess of the neat-line dimensions are incorporated into the unit prices for filter, drain, and riprap bedding zones of the dam.

F-2.1.3 Bidding Assumptions

All pricing assumes that contractors are qualified and experienced in the construction of large engineered embankment dams. It also assumes that contractors will calculate and offer construction pricing from an open and competitive approach to equipment production and material pricing and will not include allowances for changes, extra work, unforeseen conditions, or other unplanned costs.

F-2.2 Construction Cost - Project Features

F-2.2.1 General Requirements

General requirements cover the salaried payroll costs (salary, insurance, taxes and fringe benefits) for management, supervisory, engineering, administrative, and safety employees. These employees cover the contractor's jobsite project management, document control, submittal preparation, surveying and field engineering and quality control costs. Recurring jobsite overhead expenses such as office rentals, utility bills, maintenance expenses for jobsite facilities are covered under general requirements as are non-recurring expenses such as the purchase of office, engineering and safety equipment, and outside engineering and surveying expenses.

Mobilization expenses include costs to furnish and set up temporary facilities, utilities, and roads at the site preparatory to undertaking construction work. Also included are costs for transporting construction equipment to site, unloading and assembly of the equipment, and breakdown and load out expense at the end of construction.

F-2.2.2 Site Preparation

This item includes construction and improvement of existing access roads (including the 2 miles of Calaveras Road immediately to the north of the gated entrance to the site), layout and construction of haul roads, environmental protection, erosion and sediment control, demolition and removal of existing structures, abandonment and sealing existing structures, stripping of excavation, foundation and borrow areas, drying and processing borrow areas, pre-wetting borrow and excavation areas, as needed, diverting and de-watering surface and groundwater. Quantities were calculated for some of these activities where there is design detail. They are identified by units of measure in the estimated construction cost and have been priced using historical and database unit prices. Other activities without design detail have been priced as lump sum allowances in the estimated construction cost based on experience on similar projects.

F-2.2.3 Dam Foundation

Dam foundation work includes excavate, load and haul the materials that are removed from the foundation and abutments to the disposal areas shown on Figure 7-1 (in the CER); foundation clean-up; preparation and leveling of the core foundation; dewatering and groundwater control; cutoff wall; and set up, mix and injection of grout for grout curtain. Foundation excavation rates were priced per cubic yard assuming Caterpillar 777 truck and loader/excavator equipment spreads and the prices compared with historical and database unit prices. Cleaning and preparation of foundation were priced per square yard using historical and database unit prices. Treatment of the landslide on the right abutment will probably entail a combination of stabilization (including tiebacks and drainage) and shaping. For conceptual level estimation, an allowance for this treatment was included in the estimates.

The grout curtain does not have design detail at this level of development and has been quantified by measuring an estimated area of the curtain. A historical database unit price per square foot of grout curtain has been used to provide a cost allowance for the grout curtain. The costs for the secant pile cutoff wall in the left abutment were based on construction costs provided by industry specialty contractors. Although a cutoff wall in the left abutment has been used for the replacement dam, a grout curtain will be considered further during final design studies.

F-2.2.4 Embankment

Embankment construction includes providing materials, labor, and equipment for the construction of the core, shells, filter and drain zones, armoring of the upstream face of the embankment with riprap, and instrumentation for monitoring the performance of the dam.

As stated in the CER, the spillway excavation (Temblor Sandstone) will provide materials for embankment shell construction. The cost of excavation to provide these materials is included in the unit price for the shell zones. The cost for excavation of material in excess of that required for the embankment shells is included in the spillway cost. The excess materials would be placed in one of the disposal areas. The estimated amount of materials that would be placed in the dam and the amount for reserve/disposal are included in the material balance diagram (Figure 7-9 in the CER text).

Costs for excavation in the spillway are based on production drilling and blasting in the Temblor Sandstone.

Core and Shell Materials

Estimated costs for core materials include excavating, loading, hauling, placing and compacting shell zone material from Borrow Area E at the southern end of the reservoir. Estimated costs for shell materials include excavating, loading, hauling, placing, and compacting shell zone material from the spillway excavation. Pricing was developed from estimating equipment application and production and compared with historical database unit prices. Production rates were based on ten-hour shifts, double shifts and five-day workweeks. The costs associated with developing a haul road along the perimeter (east shore) of the reservoir are included as a separate line item under Site Preparation.

Chimney and Blanket Filters and Drains

Estimated costs for filter and drain materials include purchasing, transporting and placing in stockpiles, loading from stockpiles, hauling, placing, and compacting chimney and blanket filters and drains in the dam. Unit pricing for the filter and drain materials is based on purchase and transport quotes from Mission Valley Ready Mix as described in TM 5.3 (URS, 2005d) plus an allowance for freight, taxes and placement in the dam.

Riprap Bedding and Riprap

Estimated costs for riprap and bedding are based on developing the on-site blueschist quarry (Borrow Area B2) and include production costs, loading, hauling, and placing. On-site production (crushing and screening) of riprap bedding was assumed due to the excessive cost associated with the purchase and transport from commercial sources that could meet the preliminary material specifications (URS, 2005d).

F-2.2.5 Hydraulic Structures

Hydraulic structures include a new tower, extension of the downstream outlet pipe, and spillway. The tower structure and outlet pipe extension were priced as unit price and lump sum allowances based on historical costs for similar structures. Procurement costs for the gates and valves were obtained from similar equipment used on other projects. Historical database unit prices were also used to estimate the cost of the spillway concrete.

F-2.3 Escalation

It is assumed that because of the 2½-year construction duration that contractors will accommodate for escalation in their pricing. Pricing in this appendix is in 4th quarter 2004 U.S. dollars (when the construction cost estimate was performed), and escalated to 4th quarter 2005 dollars. Allowance has also been made for escalation to the construction period in Section 9 of the CER text. The cost estimate is based on the construction industry at the time the estimate was prepared and input from SFPUC. Potential issues that could affect future estimates include the bid climate of the construction industry when the work is actually bid, actual increases in prevailing wage rates, and unpredictable fluctuations in material and equipment prices.

F-2.4 Contingency

F-2.4.1 Design Contingency (Unlisted Items Allowance)

A conceptual design has unlisted items, quantities, requirements and constraints that have not been fully identified, or else are not fully investigated or designed. In later stages of design, the scope of the project also tends to expand as more detail is developed and as regulatory agencies undertake more detailed reviews.

A design contingency is, therefore, incorporated into and becomes an integral part of the estimated construction cost to accommodate those features of the work that cannot be adequately assessed due to the partially developed design. The amount of contingency reflects both the degree of risk associated with uncertainties, particularly with respect to geotechnical conditions, and the completeness of the design detail for the major elements of work. The design contingency is based on, and added to, the subtotal of construction costs because it represents an unknown portion of the total estimated construction cost. The contingency will decrease as the project moves forward into final design as more information becomes available, project requirements become better defined, and more of the design detail is captured in the subtotal of construction costs.

During preparation of this estimate, the potential risks associated with several major constructability issues were considered that include surface and groundwater management, borrow area development, material processing and haul distances, foundation conditions and extent of grout curtain/cutoff wall construction. A 30 percent design contingency was used for a conceptual-level estimate and is primarily an unlisted items allowance. This percentage is typically used for concept/planning-level dam construction cost estimates.

F-2.4.2 Construction Contingency

A construction growth contingency should be planned to pay for the costs of owner-directed changes after the project is under contract, changed conditions that occur or are encountered during construction, and other unforeseen conditions or changes. Construction growth costs are often associated with unexpected, or variations in expected, subsurface conditions. An overall construction contingency allowance equal to 10 percent of the construction contract cost is recommended to be included in the total project cost.

F-3 REFERENCES

Association for the Advancement of Cost Engineering International (AACE) (1998). Recommended Practice No. 18R-97, Cost Estimate Classification System, June.

URS (2004a). Calaveras Dam Conceptual Engineering, Spillway and Outlet Works (Task 7.0), Draft, July.

URS (2004b). Calaveras Dam Conceptual Engineering, Existing Dam Remediation Alternatives (Task 9.1), Draft, July.

URS (2004c). Calaveras Dam Conceptual Engineering, Evaluation of Replacement and Enlarged Dam Alternatives (Task 9.2), Draft, July.

URS (2004d). Calaveras Dam Conceptual Engineering, Operation of Reservoir/Storage and Bypass Requirements During Construction (Task 11.1), Draft, July.

URS (2004e). Calaveras Dam Conceptual Engineering, Cost Estimates of Alternatives, Cost Estimate Backup (Task 13), November.

URS (2005a). Calaveras Dam Conceptual Engineering, Geotechnical Data Report, Final, January.

URS (2005b). Calaveras Dam Conceptual Engineering, Geotechnical Interpretive Report, Final, January.

URS (2005c). Calaveras Dam Conceptual Engineering, Cost Estimates of Alternatives, (Task 13), Final, March.

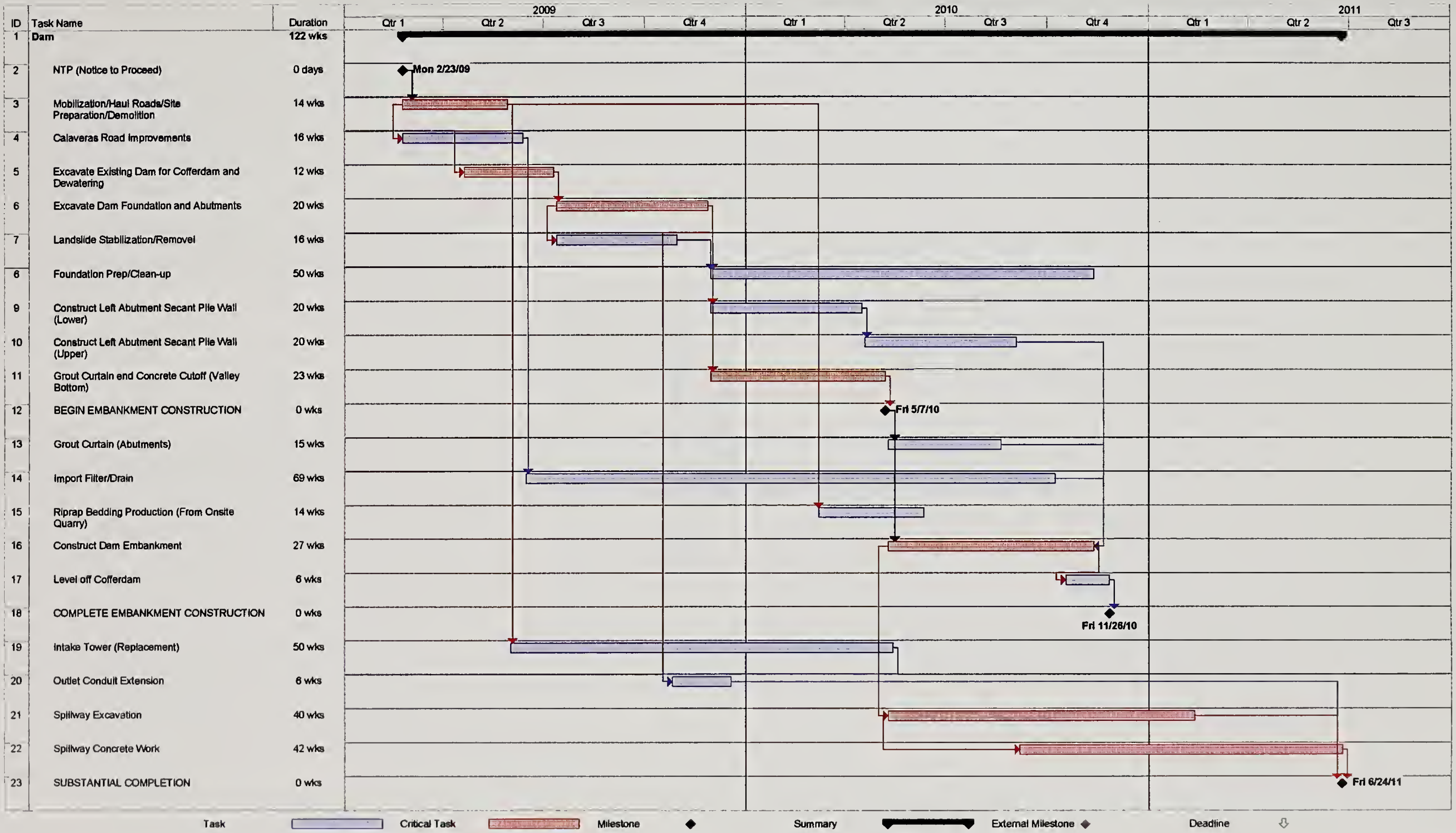
URS (2005d). Calaveras Dam Conceptual Engineering, Commercial Materials Source Assessment, (Task 5.3), Final, March.

TABLE F-1
Construction Cost Estimate
CALAVERAS REPLACEMENT DAM

No.	ACTIVITY	Quantity-UOM		Unit Cost	Estimated Cost	%
1	**General Requirements and Mobilization**					
	1.1 Construction Administration	30	mo	$ 150,000	$ 4,500,000	
	1.2 Quality Control	30	mo	$ 70,000	$ 2,100,000	
	1.3 Temporary Facilities & Mobilization		LS		$ 3,300,000	
				Subtotal	$ 9,900,000	6.9
2	**Site Preparation**					
	2.1 Demolition		LS		$ 1,000,000	
	2.2 Stripping Foundation and Borrow Areas	70	acre	$ 4,000	$ 280,000	
	2.3 Water Management	Allowance			$ 250,000	
	2.4 Reservoir Perimeter Haul roads	5	mile	$ 375,000	$ 1,875,000	
	2.5 Misc Access Roads		LS		$ 320,000	
	2.6.1 Calaveras Rd Improvements	2	mile	$ 2,500,000	$ 5,000,000	
	2.6.2 Calaveras Rd Paving	Allowance			$ 2,000,000	
	2.7 Erosion and Sediment Control		LS		$ 125,000	
				Subtotal	$ 10,850,000	7.5
3	**Dam Foundation**					
	3.1 Excavation (Foundation)	1,000,000	cyd	$ 4.80	$ 4,800,000	
	3.2 Excavation (Cofferdam)	765,000	cyd	$ 3.40	$ 2,601,000	
	3.3 Excavation (Level off Cofferdam)	600,000	cyd	$ 1.00	$ 600,000	
	3.4 Dewatering, Groundwater Control		LS		$ 1,700,000	
	3.5 Prepare Shell Foundation	87,000	syd	$ 3.00	$ 261,000	
	3.6 Prepare Core Foundation	20,000	syd	$ 13.00	$ 260,000	
	3.7 2-Row Grout Curtain & Conc Cutoff	70,000	sft	$ 28.00	$ 1,960,000	
	3.8 Secant Pile Cutoff (Note 1)	41,000	sft	$ 200.00	$ 8,200,000	
	3.9 Landslide Stabilization/Removal		LS		$ 1,000,000	
				Subtotal	$ 21,382,000	14.9
4	**Embankment**					
	4.1 Core	520,000	cyd	$ 8.50	$ 4,420,000	
	4.2 Earthfill Shell	1,520,000	cyd	$ 8.15	$ 12,388,000	
	4.3 Filter	155,000	cyd	$ 51.40	$ 7,967,000	
	4.4 Drain	115,000	cyd	$ 49.30	$ 5,669,500	
	4.5 Bedding	10,000	cyd	$ 22.00	$ 220,000	
	4.6 Riprap	30,000	cyd	$ 18.00	$ 540,000	
	4.7 Dam Instrumentation/ADAS		LS		$ 300,000	
	4.8 Permanent on-site access roads		LS		$ 1,000,000	
	4.9 Seeding/Site Restoration	Allowance			$ 3,000,000	
				Subtotal	$ 35,504,500	24.7
5	**Hydraulic Structures**					
	5.1 Outlet Conduit Extension		LS		$ 1,820,000	
	5.2 New Intake Tower		LS		$ 5,100,000	
	5.3 Spillway (Coarse Ex)	1,130,000	cyd	$ 6.00	$ 6,780,000	
	5.4 Spillway (Fine Ex & Structure)		LS		$ 12,400,000	
	5.4 Potassium Perm Bldg/Chem Treatment (N	Allowance			$ 3,000,000	
				Subtotal	$ 29,100,000	20.2
	Construction Cost Raw Estimate (4th Quarter 2004 dollars)				$ 106,737,000	
	Construction Cost Raw Estimate (4th Quarter 2005 dollars)				$110,600,000	
	Design Contingency/Unlisted Items Allowance (30%)				$ 33,180,000	23.1
	Engineer's Class 4 Estimated Replacement Dam Construction Cost				**$ 143,780,000**	100.0

Note 1. $1M added for Prime Contractor to prepare and maintain access to the slope

Nore 2: Cost provided by SFPUC



ID	Task Name	Duration
1	**Dam**	**122 wks**
2	NTP (Notice to Proceed)	0 days
3	Mobilization/Haul Roads/Site Preparation/Demolition	14 wks
4	Calaveras Road Improvements	16 wks
5	Excavate Existing Dam for Cofferdam and Dewatering	12 wks
6	Excavate Dam Foundation and Abutments	20 wks
7	Landslide Stabilization/Removel	16 wks
8	Foundation Prep/Clean-up	50 wks
9	Construct Left Abutment Secant Pile Wall (Lower)	20 wks
10	Construct Left Abutment Secant Pile Wall (Upper)	20 wks
11	Grout Curtain and Concrete Cutoff (Valley Bottom)	23 wks
12	BEGIN EMBANKMENT CONSTRUCTION	0 wks
13	Grout Curtain (Abutments)	15 wks
14	Import Filter/Drain	69 wks
15	Riprap Bedding Production (From Onsite Quarry)	14 wks
16	Construct Dam Embankment	27 wks
17	Level off Cofferdam	6 wks
18	COMPLETE EMBANKMENT CONSTRUCTION	0 wks
19	Intake Tower (Replacement)	50 wks
20	Outlet Conduit Extension	6 wks
21	Spillway Excavation	40 wks
22	Spillway Concrete Work	42 wks
23	SUBSTANTIAL COMPLETION	0 wks

URS

26814817

Calaveras Dam Replacement Project

CONCEPTUAL LEVEL CONSTRUCTION SCHEDULE FOR REPLACEMENT DAM

Figure F-1

\x_geo\Calaveras CER\Task 14\Final CER Figures\Figure F-1.ai

Appendix F-1

Cost Estimate Back-Up

Activity / Feature
Project Calaveras Replacement Dam
Location Eastern San Francisco Bay Region, California
Owner / Client San Francisco PUC

Effectivi 10/30/04
Class Four
Currenc US $

1 GENERAL REQUIREMENTS AND MOBILIZATION

SPEC.	DESCRIPTION	QUANTITY	UOM	LABOR	EQUIPMENT	MATERIAL	SUB CONTRACT	TOTAL DIRECT COST	UNIT PRICE (no indirects)	G & A	PROFIT	BOND	TOTAL COST	UNIT PRICE	PRESENTATION TABLE		
01300.0	Construction Administration									-	-	-	-				
	Management and Coordination	30.0	MO	786,000	144,000			930,000	31,000.00	46,500	97,650	10,742	1,084,892	36,163.05	1.1	1.1	4,403,609.60
	Progress Documentation, Submittals	30.0	MO	474,000	66,000			540,000	18,000.00	27,000	58,700	6,237	629,937	20,997.90	1.1	1.2	2,033,297
01400.0	Quality Requirements									-	-	-	-			1.3	3,319,768
	Quality Control	30.0	MO	1,455,000	288,000			1,743,000	58,100.00	87,150	183,015	20,132	2,033,297	67,778.56	1.2	2.7	126,104.06
01500.0	Temporary Facilities and Mobilization									-	-	-	-				
	Utilities and Facilities	30.0	MO	360,000	1,050,000	45,000		1,455,000	48,500.00	72,750	152,775	16,805	1,697,330	56,577.68	1.3		
	Construction	30.0	MO	135,000	458,000	285,000		876,000	29,200.00	43,800	91,980	10,118	1,021,898	34,063.26	1.3		
	Equipment Mobilization	40.0	EA	170,000	344,800			514,800	12,870.00	25,740	54,054	5,948	600,540	15,013.50	1.3		
	Controls Erosion and Sediment	1.0	LS	29,600	78,500			108,100	108,100.00	5,405	11,351	1,249	126,104	126,104.06	2.7		
01700.0	Execution									-	-	-	-				
	Layout and Survey	30.0	MO	726,000	126,900			852,900	28,430.00	42,645	89,555	9,851	994,950	33,165.02	1.1		
	Closeout	30.0	MO	474,000	66,000			540,000	18,000.00	27,000	56,700	6,237	629,937	20,997.90	1.1		
01800.0	Operations									-	-	-	-				
	Startup and Training	30.0	MO	381,000	75,000			456,000	15,200.00	22,800	47,880	5,267	531,947	17,731.58	1.1		
	Operations and Maintenance	30.0	MO	381,000	75,000			450,000	15,200.00	22,800	47,880	5,267	531,947	17,731.56	1.1		
	GENERAL REQUIREMENTS AND MOBILIZATION			5.371.600	2.770.200	330.000		8.471.800		423,590	889,539	97,849	9,882,778	329.425.94			
								8.471.600					9.882.778	-			

2 SITE PREPARATION

SPEC.	DESCRIPTION	QUANTITY	UOM	LABOR	EQUIPMENT	MATERIAL	OTHER	TOTAL COST	UNIT PRICE (no indirects)	G & A	PROFIT	BOND	TOTAL COST	UNIT PRICE			
	SITE CONSTRUCTION									-	-	-	-				
	Demolition									.	-	-	-				
02220.0	Remove Riprap Existing Dam	10,000.0	CY	14,000	42,000			56,000	5.80	2,800	5,880	647	65,327	8.53	2.1	2.1	1,041,321
02220.0	Remove Concrete Spillway	5,000.0	CY	105,000	305,000			410,000	82.00	20,500	43,050	4,736	478,286	95.66	2.1	2.2	279,529
02220.0	Remove Concrete Miscellaneous	1,000.0	CY	21,000	61,000			82,000	82.00	4,100	8,610	947	95,657	95.66	2.1	2.3	
02220.0	Remove Pipe Outlet	1,500.0	LF	27,000	82,500			109,500	73.00	5,475	11,498	1,265	127,737	85.16	2.1	2.4	1,875,812
02220.0	Remove Building Pot. Perm.	500.0	CY	1,750	6,750			0,500	17.00	425	893	98	9,916	19.83	2.1	2.5	314,969
02220.0	Remove Asphalt County Road	5,500.0	SY	14,300	42,350			56,650	10.30	2,833	5,948	654	66,065	12.02	2.1	2.6	5,027,831
02220.0	Remove Fence	10,000.0	LF	8,500	23,500			30,000	3.00	1,500	3,150	347	34.997	3.50	2.1		
02220.0	Remove Power Lines	2,500.0	LF	35,000	105,000			140,000	56.00	7,000	14,700	1,617	163,317	65.33	2.1		
	Site Clearing									-	-	-	-				
02230.0	Clear and Grubb Borrow	30.0	AC	8,240	22,140			28,380	946.00	1,419	2,980	328	33,107	1,103.56	2.2	3.4	1,695,464
02230.0	Clear and Grubb Foundation	25.0	AC	7,100	25,150			32,250	1,290.00	1,613	3,388	372	37.621	1,504.85	2.2		
02230.0	Clear and Grubb Disposal	15.0	AC	3,120	11,070			14,190	948.00	710	1,490	184	16,553	1,103.56	2.2		
02230.0	Topsoil Stockpile Borrow	35,000.0	CY	15,750	56,350			72,100	2.06	3,605	7,571	833	84,108	2.40	2.2		
02230 0	Topsoil Stockpile Foundation	35,000.0	CY	15,750	56,350			72,100	2.06	3,605	7,571	833	84,108	2.40	2.2		
02230 0	Topsoil Stockpile Disposal	10,000.0	CY	4,500	16,100			20,600	2.06	1,030	2,163	238	24.031	2.40	2.2		
	Dewatering									-	-	-	.				
02240.0	Wells w/ Pumps	18.0	EA	68,400	241,200	387,000		696,600	38,700.00	34,830	73,143	8,046	812,619	45,145.49	3.4		
02240.0	Discharge Piping	10,000.0	LF	23,000	93,000	180,000		296,000	29.60	14,800	31,080	3,419	345,299	34.53	3.4		
02240.0	Operate and Maintain Pumps	24.0	MO	115,200	345,600			460,800	19,200.00	23,040	48,384	5,322	537.546	22,397.76	3.4		
	Site Access and Haul Roads									-	-	-	.				
02315.0	Haul Roads Disposal Area	3,000.0	LF	20,100	69.900			00,000	30.00	4,500	9,450	1,040	104,990	35.00	2.5		
02315.0	Haul Roads Quarry	3,000.0	LF	20,100	69,900			90,000	30.00	4,500	9,450	1,040	104.990	35.00	2.5		
02315.0	Haul Roads Core Borrow	24,000.0	LF	360,000	792,000	458,000		1,600,000	87.00	80,400	168,840	18,572	1,875.812	78.16	2.4		
02315.0	Haul Roads Shell Borrow	3,000.0	LF	20,100	69,900			90,000	30.00	4,500	9,450	1,040	104,990	35.00	2.5		
02315.0	Calaveras Road Improvements	10,000.0	LF	640.000	1,450,000	2.220.000		4,310,000	431.00	215,500	452,550	49,781	5,027,831	502.78	2.6		
	SITE PREPARATION			1.618.910	4.232.760	3.243.000		9,094,670		454,734	054,940	105,043	10,609,307	10.809.387.29			

DIRECT SUMMARY PAGE
FINAL

Activity / Feature		Effectiv	10/30/04
Project	Calaveras Replacement Dam	Class	Four
Location	Eastern San Francisco Bay Region, California	Currenc	US $
Owner / Client	San Francisco PUC		

3 DAM

SPEC.	DESCRIPTION	QUANTITY	UOM	LABOR	EQUIPMENT	MATERIAL	OTHER	TOTAL COST	UNIT PRICE (no Indirects)	G & A	PROFIT	BOND	TOTAL COST	UNIT PRICE				
	SITE CONSTRUCTION																	
	Excavation									-	-	-	-					
02315.0	Excavation Open Channel Spillway to Shell	1,320,000.0	CY	2,112,000	4,554,000			6,666,000	5.05	333,300	699,930	76,992	7,776,222	5.69	4.2			SubTotals
02315.0	Excavation Dam Foundation to Waste	1,000,000.0	CY	950,000	3,150,000			4,100,000	4.10	205,000	430,500	47,355	4,782,855	4.78	3,1	3.1	$	4,782,855
02315.0	Excavation Cofferdam to Waste	765,000.0	CY	535,500	1,683,000			2,218,500	2.90	110,925	232,943	25,624	2,587,991	3.38	3.2	3.2	$	2,587,991
02315.0	Excavation Cofferdam to Disposal Area 2	600,000.0	CY	120,000	390,000			510,000	.85	25,500	53,550	5,891	594,941	0.99		3.3	$	594,941
02315.0	Excavation Borrow Area E Core	580,000.0	CY	377,000	1,189,000			1,566,000	2.70	78,300	164,430	18,087	1,826,817	3.15	4,1	3.5	$	263,874
02315.0	Excavation Salvage and Borrow Area B1	30,000.0	CY	80,000	139,500			199,500	6.65	9,975	20,948	2,304	232,727	7.76	4.5, 4.6	3.6	$	257,108
02315.0	Landslide Stabilization and Shaping	400,000.0	CY	180,000	680,000			840,000	2.10	42,000	88,200	9,702	979,902	2.45	3,7	3.7	$	1,959,629
	Embankment									-	-	-	-			3.8	$	7,174,283
02330.0	Prepare Shell Foundation	87,000.0	SY	58,550	189,650			220,200	2.60	11,310	23,751	2,813	263,874	3.03	3,4	3.9	$	979,902
02330.0	Clean and Prepare Core Foundation	20,000.0	SY	58,400	184,000			220,400	11.02	11,020	23,142	2,546	257,108	12.86				
02330.0	Core Borrow Are E	520,000.0	CY	572,000	1,822,400			2,194,400	4.22	109,720	230,412	25,345	2,559,877	4.92	4,1	4.1	$	4,388,695
02330.0	Shell Open Channel Spillway	1,520,000.0	CY	1,084,000	2,842,400			3,906,400	2.57	195,320	410,172	45,119	4,557,011	3.00	4.2	4.2	$	12,333,233
02330.0	Filter Blanket Filter Sand Imported	72,000.0	CY	190,800	507,600	2,476,800		3,175,200	44.10	158,760	333,398	36,874	3,704,030	51.44	4.3	4.3	$	7,973,953
02330.0	Drain Blanket Drain Rock Imported	59,000.0	CY	154,580	395,300	1,942,280		2,492,180	42.24	124,608	261,677	28,784	2,007,229	49.28	4,4	4.4	$	5,666,633
02330.0	Filter Chimney Filter Sand Imported	63,000.0	CY	219,950	585,150	2,855,200		3,660,300	44.10	183,015	364,332	42,276	4,269,923	51.44	4,3	4.5	$	224,211
02330.0	Drain Chimney Drain Rock Imported	58,000.0	CY	146,720	375,200	1,843,520		2,365,440	42.24	118,272	248,371	27,321	2,759,404	49.28	4.4	4.6	$	529,077
	Erosion and Sediment Control									-	-	-	-			4.7	$	260,841
02370.0	Riprap Bedding Borrow Area B1	10,000.0	CY	49,000	86,200			135,200	13.52	8,760	14,196	1,562	157,718	15.77	4.5	4.8		
02370.0	Riprap From Borrow Area B1	27,000.0	CY	105,300	205,740			311,040	11.52	15,552	32,659	3,593	362,844	13.44	4.6	4.9	$	250,808
	Foundation Walls									-	-	-	-				$	50,226,032
02450.0	Grout Curtain 2 Row Perm	70,000.0	SF	184,800	525,000	273,000		982,600	14.04	49,140	103,194	11,351	1,146 485	18.38	3.5			OK
02450.0	Concrete Cut Off Wall	15,000.0	SF	184,500	145,050	367,500		607,050	46.47	34,853	73,190	8,051	813,144	54 21	3,5			
02450.0	Concrete Secant Wall Left Abutment	41,000.0	SF				6,150,000	6,150,000	150.00	307,500	845,750	71,033	7,174,283	174.98	3.6			
02495.0	Monitoring Survey, Benchmarks	36.0	EA	6,840	24,120	46,440		77,400	2,150 00	3,870	8,127	894	00,291	2,508.08	4.7			
02920.0	Plantings Seed and Fertlizers	100.0	AC	40,700	122,000	52,300		215,000	2,150 00	10,750	22,575	2,483	250,808	2,508.08	4.9			
00013.0	INSTRUMENTATION									-	-	-	-					
13500.0	Piezometers	20.0	EA	11,680	34,940	99,800		140,200	7,310 00	7,310	15,351	1,689	170,550	8,527.48	4.7			
										-	-	-	-					
										-	-	-	-					
										-	-	-	-		4-10			
	DAM			7,358,300	10,590,250	0,956,640	6,150,000	43,055,100		2,152 760	4 520,795	497 287	50,226,032	21 40				

Activity / Feature
Project Calaveras Replacement Dam
Location Eastern San Francisco Bay Region, California
Owner / Client San Francisco PUC

Effectiv 10/30/04
Class Four
Currenc US $

4 SPILLWAY

SPEC.	DESCRIPTION	QUANTITY	UOM	LABOR	EQUIPMENT	MATERIAL	OTHER	TOTAL COST	UNIT PRICE (no indirects)	G & A	PROFIT	BOND	TOTAL COST	UNIT PRICE			
	SITE CONSTRUCTION																
	Excavation Support and Protection									.	.	.	.				
02490.0	Soil and Rock Anchors	36,000.0	LF	406,800	1,224,000	784,800		2,415,600	67.10	120,780	253,638	27,900	2.817.918	78.28	5.4		SubTotals
02315.0	Excavation Rock to Waste	1,130,000.0	CY	1,457,700	4,248,800			5,706,500	5.05	285,325	599,183	65,910	6,658,918	5.89	5.3	5.3	$ 6,656,918
02315.0	Backfill	12,500.0	CY	22,875	68,500			91,375	7.31	4,569	9,594	1,055	106.594	8.53	5.4	5.4	$ 12,432,944
	CONCRETE									-	-	-	-				$ 19,089,862
03200.0	Concrete Reinforcement	2,380,000.0	LB	523,600	190,400	1,142,400		1,856,400	.78	92,820	194,922	21,441	2.165.583	0.91	5.4		OK
03300.0	Concrete Cast-In-Place Slabs	5,000.0	CY	645,000	155,000	1,165,000		1,965,000	393.00	98,250	206,325	22,696	2,292,271	458.45	5.4		
03300,0	Concrete Cast-In-Place Walls	7,500.0	CY	967,500	232,500	2,497,500		3,697,500	493.00	184,875	388,238	42,706	4.313.319	575,11	5.4		
03300.0	Concrete Backfill	1,600.0	CY	184,000	49,600			233,600	146.00	11,680	24,528	2,698	272,506	170.32	5.4		
03300.0	Concrete Dental	1,600,0	CY	184,000	49,600	164,800		398,400	249.00	19,920	41,832	4,602	464.754	290.47	5.4		
										-	-	-	-				
										-	-	-	-				
	SPILLWAY			4,391,475	6,218,400	5,754,500		16,364.375		818,219	1,718,259	189,009	19,089,862	561.47			
								16,364,375					19,089,862				

5 OUTLET WORKS

SPEC.	DESCRIPTION	QUANTITY	UOM	LABOR	EQUIPMENT	MATERIAL	OTHER	TOTAL COST	UNIT PRICE (no indirects)	G & A	PROFIT	BOND	TOTAL COST	UNIT PRICE			
	PIPE									-	-	-	-				
02840.0	Pipe 6'x6'x6' Dia. Steel Bifurcation	7,000.0	LB	3,570	12,110	21,840		37,520	5.38	1,876	3,940	433	43,769	6.25	5.1	5.1	1,821,883
02640.0	Pipe 8' Dia. Steel Outlet Conduit	650.0	LF	65,650	139,100	241,800		446,550	687.00	22,328	46,888	5,158	520,923	801.42	5.1		
02640.0	Pipe 6' Dia. Steel Outlet Conduit Extension	350.0	LF	35,350	74,900	130,200		240,450	687.00	12,023	25,247	2,777	280,497	801.42	5.1		
	CONCRETE									-	-	-	-				
03300.0	Concrete Cast-In-Place Valve Vault	50.0	CY	7,550	3,200	17,500		28,250	565.00	1,413	2,968	326	32,955	659.10	5.1		
	EQUIPMENT									-	-	-	-				
11285.0	8' Dia. Shut Off Val. W/ Oper.	1,0	EA	42,000	10,000	401,000		453,000	453,000.00	22,650	47,565	5,232	528,447	528,447.15	5.1		
11285.0	6' Dia, Fixed Cone Val. W/ Oper.	1.0	EA	31,000	10,000	315,000		358,000	356,000.00	17,800	37,380	4,112	415,292	415,291.80	5.1		
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
										-	-	-	-				
	OUTLET WORKS			165.120	249.310	1.127.340		1.581.770		70,009	163,988	10,030	1,821,003	1.821.88			

Cost Estimate - New Intake Tower

ID	Description	Quantity	UOM	Unit Price	Cost	Comments
1	Intake Tower Shaft					
1a	Shaft excavation & muck disposal	2168	CY	$120	$260,160	Unit cost from Chris Mueller
1b	10' Long Rock Dowels	86	EA	$570	$49,020	Unit cost from Chris Mueller
1c	Shotcrete	10,560	SF	$9.00	$95,040	Unit cost from Chris Mueller
1d	Cast in Place Reinforced Concrete	923	CY	$830	$766,090	Unit cost from Roy Watts tower estimate, (including resteel w/concrete)
2	Tunnels to Existing/New Adits					
2a	40-ft long tunnel to Tower Adit 1	NA	LS	NA	$47,000	Hand excavation & grout
2b	40-ft long tunnel to Tower Adit 2	NA	LS	NA	$47,000	Hand excavation & grout
2c	90-ft long trench for Adit 3	2500	CY	$20	$50,000	Open excavation & backfill
3	Break in/attach for Adits					
3a	Break in to 72" Pipe	NA	LS	NA	$100,000	Allowance, Includes 90 degree bend
3b	Attach to Adit 1	NA	LS	NA	$25,000	Allowance
3c	Attach to Adit 2	NA	LS	NA	$25,000	Allowance
4	Demo existing tower					
4a	Blind flange in 5-ft ID pipe	NA	LS	NA	$20,000	Allowance
4b	Backfill concrete shaft portion of structui	600	CY	$120	$72,000	Fill existing tower to elevation 740
4c	Remove and Dispose (E)60" Standpipe	NA	LS	NA	$150,000	Allowance, includes misc other removal and disposal
4d	Misc. remaining old tower	NA	LS	NA	$100,000	Allowance
5	Tower structure El 748-815					
5a	Tower cast-in-place reinforced concrete	360	CY	$830	$298,800	Unit cost from Roy Watts estimate, (including resteel w/concrete)
5b	Roof	NA	LS	NA	$20,000	Allowance for new roof
5c	Bridge	780	SF	$150	$117,000	Unit cost from Roy Watts estimate
6	Mechanical					
6a	72-inch diameter pipe riser	180	LF	$1,700	$306,000	Pacific Pipe Works $900 per foot material cost for 5/8" thickness
6b	48-inch operating and guard gates	6	EA	$150,000	$800,000	Hilton Valve quote $492,000 FOB for 6 ss316 valves
6c	60-inch operating and guard gates	2	EA	$230,000	$460,000	Hilton Valve quote $268,000 FOB for 2 ss316 valves
6d	48-inch pipe in tunnel (Adits 1 and 2)	36000	LBS	$3.50	$126,000	140 LF. Same price per pound installed as 72-inch pipe
6e	60-inch pipe in trench (Adit 3)	30000	LBS	$3.50	$105,000	90 LF. Same price per pound installed as 72-inch pipe
6f	Relocate Adit No. 3 Screen	NA	LS	NA	$20,000	Allowance
6g	Elevator System	1	LS	$400,000	$400,000	Geoff Kittell of ThyssenKrupp Elevator quote for $350,000, not installed.
6h	HVAC System	1	LS	$15,000	$15,000	YEI Allowance
7	Electrical					
7a	Control System				$60,000	YEI Allowance
7b	General electrical/lighting				$20,000	YEI Allowance
7c	Backup generator system, 300 kW				$110,000	Dennis McNamee of Onan Generator quote for $90,000 uninstalled
7d	PG&E Service				$85,000	300 kVA pad mounted transformer
8	Misc Metal; stairs and platforms				$350,000	This item cost $200,000 in 1991
	Total				**$5,099,110**	

Cost Estimate - Upgrade of Existing Intake Tower

ID	Description	Quantity	UOM	Unit Price	Cost	Comments
1	Backup power	NA	LS	NA	$0	Backup power consisting of twist lock mobile generator system is already being implemented at the site as part of another contact. Power supply could be made more secure through the installation of a backup generator. (Allowance cost, if needed, $200,000).
2	Remote indication of valve position	3	EA	$7,000	$21,000	Allow operation from platform at elevation 780.
3	Hoist system	NA	LS	NA	$200,000	Allowance to demo grating on left side of tower at 4 platform locations and install a means for delivering tools and repair materials to the various operating levels in the tower.
4	Seismic upgrade of tower					
4a	Rock excavation	200	CY	$120	$24,000	Excavate 20 feet into rock
4b	Reinforced concrete	200	CY	$2,000	$400,000	Walls thickened with one foot of reinforced concrete
4c	Roof structural upgrade	NA	LS	NA	$30,000	Structural member to support winch
4d	Deck and new door	NA	LS	NA	$20,000	New entrance door and access to it
4e	Electrical	NA	LS	NA	$30,000	Allowance to relocate electrical in case of interference
5	Seismic upgrade of access bridge	NA	LS	NA	$100,000	Upgrade and separate bridge from tower
6	Drain line cleanout/sump pump	NA	LS	NA	$20,000	Sump and booster pump to improve performance of drain
	Total				**$845,000**	

Appendix G

Responses to Comments from CTAP Meeting No. 4 and SFPUC

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
1	1.a	3	With the regard to the secant wall, the CTAP continues to have some concerns about the viability of constructing such a wall on the steep left abutment. Without doubt, problems inherent to construction of such a wall will be magnified by the difficulty of the steep slope construction. The CTAP also notes that the schedule indicates time for construction of the wall to be somewhat less than two quarters. The CTAP believes that schedule may be overly optimistic. Also, costs indicated for the secant wall, while considerably higher than for a grout curtain, need to be reviewed. Recent experience concerning panel wall construction indicated somewhat higher costs.	(a) Concur. The difficulties with constructing a cutoff wall on the steep abutment slope are recognized and will be fully addressed during final design, after the final geotechnical investigation has been completed. (b) Concur. The schedule and cost will be reviewed, and revised if needed, for the final CER.
2	1.b	3	With regard to a grout curtain, the CTAP recognizes that there have been recent advances in the techniques and grout mixes. The CTAP recommends that these new techniques be evaluated for use in the grouting programs to be used at Calaveras Dam.	Concur. The recent advances in techniques and grout mixes will be evaluated during final design.
3	2.a	4	We are reluctant to endorse the need to use soil improvement of any of the original embankment left in place to support the upstream shell of a raised dam. We believe alternatives can be found to avoid this restriction to any future raised design. The CTAP suggests that during final design, optimization of the dam axis location could allow the footprint to move somewhat downstream providing added area for any raised dam to be founded on foundation rock. The other possibility would be to locally remove more of the lower portion of the existing embankment than presently shown. Depending on the construction stability that can be attained, local steepening of the slope may be possible. Consideration could also be given to the use of a tie-back retaining wall which has proven very effective on other projects.	Concur. We agree that optimization of the dam axis location will be addressed during final design. Also, options such as local steepening of the slope and temporary wall construction will be considered during final design.

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
4	2.b	4	The space between the existing dam crest and the new replacement embankment is planned to be used as the spoil disposal location for the upper portion of the existing dam. It would be necessary to excavate and remove this material in order to construct a raised dam. However, it is our understanding that excess spillway excavation material suitable for use in the upstream shell zone has to be wasted with haul to a more remote disposal site. The CTAP recommends that consideration be given to compacting this material in a wider upstream shell zone established to suit the limits of any future dam. This berm might extend as high as approximately El 700. Compaction of this added material would increase the construction cost by a small amount and this should be taken into consideration in comparison to the benefit to future enlargement. Comparison of the amount and cost of material disposal should be a wash under either scenario.	Concur. Placing and compacting excess Temblor Sandstone in the space between the existing dam and the replacement dam will be considered during final design.
5	3.a	5	URS is recommending that a physical model study be conducted as part of final design. A proper model study is vital, since it may be necessary to make some design changes to minimize the cross waves and their effects and to assure that the stilling basin operates properly. The model layout should include a few hundred feet of the channel downstream of the stilling basin as a moveable bed, so that the effectiveness of the energy dissipation can be assessed. The model study will also provide criteria for the size and extent of riprap protection to be provided downstream of the stilling basin.	Concur.
6	3.b.	5	The CTAP recommends that the layout of the spillway be studied further. It appears feasible to move the spillway closer to the dam. This would reduce excavation for the spillway channel and reduce the amount of waste that must be disposed of. It should also be possible to reduce the degree of curvature by moving the spillway coupled with some relocation of the crest. Any reduction of the curvature of the spillway channel would be desirable.	Concur. Optimization of dam and spillway layouts is needed and will be done during final design. (See also CER Section 11.2.2.)

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
7	3.c	5	The design envisions that the fixed cone valve, which will control emergency discharges from the reservoir, will discharge into the stilling basin. This is desirable and the physical model should include this discharge facility. The CTAP understands that the dissipation characteristics of the existing fixed-cone-valve are deficient is some ways. In order to insure that the fixed-cone-valve operates as desired and accomplishes satisfactory energy dissipation within the basin, special consideration should be given during final design of the stilling basin to assure that proper dissipation of energy occurs when the fixed-cone- valve is discharging into the stilling basin. To accomplish this it may be necessary to conduct a separate physical model study (at a larger scale than the spillway model) to finalize the placement of the valve and to design a satisfactory shroud to control spray.	We believe that it may not be necessary to model the fixed-cone valve if there is sufficient data available from operation of similar systems of fixed-cone valves discharging into stilling basins. (The existing deficiencies in operation result from the retrofit design.)
8	4.a.	6	The main concerns of the CTAP relate to the phreatic surface used for the existing dam, and to the strength parameters assigned to the various zones of the existing dam and of the proposed new dam and the underlying foundation layers. The assigned properties and the assumed phreatic surface in the existing dam result in acceptable factors of safety for steady state seepage, emergency rapid drawdown, and during construction. As noted in the response to Question No. 6, however, the available test data are not sufficient to assign strength parameters to the various zones of the new dam and to the foundation layers needed for final design. It is expected that when the additional tests have been completed and the results synthesized, the stability analyses will be repeated to check the adequacy of the design.	Concur that the available test data are not sufficient to assign strength parameters to the various zones of the new dam and to the foundation needed for final design. (The strength parameters developed to date are for the purpose of conceptual engineering.) For final design, it is intended that the additional test data results will be synthesized and the stability analyses will be repeated to check the adequacy of the design. (See CER, Section 11.2.)
9	4.b.	6	The CTAP recommends that URS include a brief discussion regarding the phreatic surface within the existing dam, including any piezometric measurement that would justify the location shown in Appendix D.	Concur. This discussion will be included in the final CER, Appendix D.

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
10	4.c.	6	The calculated deformations are highly dependent on the calculated yield acceleration for any potential sliding mass, which in turn is dependent on the strength parameters assigned to the material encompassed by that sliding mass. Therefore, any future deformation calculations should incorporate the yield accelerations derived using the strength parameters determined during the next phase of the geotechnical investigations.	Concur. See also response to No. 8.
11	4.d.	7	The CTAP recommends that future analyses of the enlarged dam exclude the part of the existing dam left in place.	Concur. We will work with SFPUC to determine when this comment should be addressed.
12	4.e.	7	If the earthquake ground motions are revised, as noted in the response to Question No. 9, it will be necessary to develop a new accelerogram whose spectrum would be compatible with the revised spectral values. Therefore, the analyses included in Appendix D will have to be repeated. It is also quite possible that more than one accelerogram would be necessary.	Concur. The deformation analyses will be repeated using new updates in the ground motions and additional accelerograms. (See CER, Section 11.2.2.)
13	4.f.	7	Finally, the amount of deformation calculated for the dams is highly dependent on the velocity time series associated with input accelerogram (see, for example, Figures D-4 and D-12C). Therefore, it would useful that an evaluation of the time series of the velocity traces of recorded motions during magnitude 7±0.25 earthquakes be conducted prior to making a final selection of the accelerogram(s) for use in final design.	Concur.
14	5.a.	7	Whether a new outlet tower is constructed, or the existing tower is reinforced, the tower should be designed for the same seismic criteria as the dam.	Concur. This seismic criterion will be used in final design.
15	5.b.	7	Some of the control valves and guard valves are very old and maybe approaching the end of useful life. Since major changes in the outlet tower and control systems are being contemplated, it would be prudent to consider replacement of these valves during construction of the replacement dam.	Concur. As clarification, we understand the valves of concern to be the 30-inch diameter drain valves at El. 602.2 ft. We will consider replacement of the downstream valves as part of final design. The valves in Adits 1, 2 and 3 were placed in service in 1992 and should have many additional years of useful life if the tower is rehabilitated. If a new tower is constructed, we expect to replace the drain valves and valves in Adits 1 and 2, blocking the existing valves in the open position. We will also consider replacement and reuse of the existing 60-inch valve in Adit 3.

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
16	6.a.	8	However, in the planned future investigations, no borehole is indicated for the stilling-basin location. Since excavation for the stilling-basin will be relatively deep, it would be advisable to locate at least one borehole in that location. It should be understood that, as these investigations proceed, it may be necessary to include additional borings, trenches … etc, to gather the information required for design of specific project components.	Concur. A boring will be added in the stilling basin location that will extend below the basin floor. We recognize that it may be necessary to include additional investigation for design of specific project components.
17	6.b.	8	In addition to the usual tests, the CTAP recommends that the following laboratory tests also be conducted as part of these investigations: • Static consolidated-undrained triaxial tests, with measurement of pore water pressure, on compacted specimens of the Temblor Sandstone. • Static consolidated-undrained triaxial tests, with measurement of pore water pressure, on compacted specimens of the core material. • Cyclic triaxial tests on compacted specimens of the Temblor Sandstone.	Concur. Such testing will be part of final design.
18	6.c.	8	The CTAP also recommends the following field tests: • In-situ testing of the Mélange within the Franciscan Formation using a pressuremeter and possibly a Goodman Jack. • Test fills of the Temblor Sandstone and of the core material be planned for implementation prior to completing final design.	Concur. (See also CER, Section 11.2.1.)
19	6.d	8	The CTAP recommends that both the field and the laboratory testing programs be developed by URS as soon as possible. The CTAP would look forward to reviewing and commenting on the document when it is submitted by URS to SFPUC.	Concur. SFPUC and URS are working to develop the field and the laboratory testing programs, which will be reviewed by the CTAP.
20	8.a.	9	The construction contingency of 10% may be somewhat low particularly to cover the foundation excavation, grouting operations and construction of the secant wall. For these specific cost items, the CTAP would recommend a contingency closer to 15% or 20%.	Concur. URS will review the appropriate construction contingency allowance with SFPUC.

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
21	9.a.	10	The Panel notes that the URS Conceptual Engineering Report of 25 April 2005 states on p. 5-5 that the MCE for the northern segment of the Calaveras fault is estimated at 6.8, and for the central segment 7.1. Yet on p. 6-1, the recommended MCE for the dam site is 7-1/4. The CTAP suggests that some rationale be given in the report for the higher end figure.	Concur. The rationale for using the **M**7¼ MCE has been developed and has been included in the draft CER as follows: *"The M7.1 is a median value for the central Calaveras fault, with a 50% probability of being exceeded. Based on the uncertainty in rupture length, and a standard deviation of 0.2 to 0.3 magnitude unit from empirical relationships, a MCE value of M7¼ for the central Calaveras fault has been adopted in the deterministic seismic hazard analysis for the conceptual design of the Calaveras Dam Replacement Project (URS, 2005c)* [Tech Memo 6.3]."
22	9.b.	10	On-going studies at the Pacific Earthquake Engineering Center (PEER) are expected to produce a new generation of earthquake ground motions attenuation relationships. These relationships are expected to become available in late 2005, at which time the spectral values for this project will be re-evaluated using some or all of the new relationships, as appropriate.	Concur. See also response to No. 12.
23	10.a.	10	The CTAP notes that the Spillway and Quarry faults have been deemed "inactive" by the DSOD, but only informally. We suggest that DSOD be formally requested to verify their acceptance.	• The DSOD concurred that the Spillway fault is inactive in their e-mail to SFPUC dated 9/23/04 (see also Tech Memo 9.3, Appendix D, last page): *"We agree with the recent interpretations by URS and WLA that the Spillway fault is inactive, and that the Gully fault and East Leyden lineament are conditionally active according to DSOD guidelines."* • The DSOD concurred that the Quarry fault is inactive in their e-mail to SFPUC dated 7/13/04: *"DSOD concurs the Quarry fault is inactive."* • Based on the above e-mails, we believe that no further action is necessary.

Summary of Comments/Recommendations From Report for the Calaveras Technical Advisory Panel, Meeting No. 4, May 10-11, 2005

No.	Comment	Ref. Page	Description	URS Proposed Response/Action
24	10.b.	11	The CTAP notes that URS is planning to salvage the riprap on the existing dam and reuse it on the replacement dam. Consideration should be given to assessing riprap sizes, which are available on the existing dam. Some reprocessing of this riprap will be required to separate into at least two size fractions before placement on the replacement dam. In order to estimate how much riprap will be available it would desirable to conduct a salvage test on a small part of the existing riprap. The assessment will provide an estimate of any additional quantities, which might need to be quarried off site.	Concur. The riprap will be evaluated during the final design geotechnical investigations. It is contemplated that the investigation can be accomplished by using a large backhoe to excavate a pit through the riprap. The trench walls and materials will be logged (and material size distribution estimated) and photographed.
25	10.c.	11	In viewing the proposed construction schedules it is obvious that considerable time will be required for foundation excavation, grouting and/or construction of a secant cutoff and other associated activities. The CTAP suggests consideration to be given to issuing an early contract for excavation and grouting and/or construction of a secant wall. The main dam construction contract could follow at a later date.	Concur. This evaluation will be done during final design. The evaluation will include an assessment of the potential for overall time savings and reduction of risk of construction delays using separate foundation construction contracts.

Calaveras Dam Replacement Project

Draft Conceptual Engineering Report, Volume 1, *Dam and Appurtenant Structures*
SFPUC Review Comments
October 11, 2005 (Rev)

No.	Ref. Page or Section	Comments	Reviewers	URS Response
1	Pg ES-3 Footnote 1 and 2	Please clarify the constraints of reservoir capacity with respect to the invert elevation of the Alameda Creek Diversion Tunnel.	Chu Liu	Concur.
2	Pg 2-2 3rd Sec 2.4.1	"A total of four intakes connect to a vertical 60-inch diameter steel riser located within the tower/shaft." Do the four intakes include the three adits and lowest drain?	Chu Liu	Yes, the four intakes include the three adits and lowest drain; this will be clarified.
3	Pg 7-2 Table 7-1	The proposed Stilling Basin is recommended to incorporate in the Table 7-1.	Chu Liu	Concur. Stilling basin length will be called out in the table.
4	Pg 7-4 2nd bullets	Please clarify the "less weather rock" description.	Chu Liu	Concur. We will clarify the term. See also Table 7-2 for descriptions of degrees of weathering.
5	Pg 7-14 Se 7.6.2	Wave actions may stir up the sediment deposits and increase the turbidity in Disposal Area 2. Please address this concern.	Chu Liu	Concur. Gravel/rock will need to be placed on the fill surface.
6	Figure 2-2	The lower X axis should be label as "Reservoir Capacity."	Chu Liu	Concur.
7	Figure 7-2	a) The 1H:1V upstream slope of the disposal dike seems steep. Please verify. b) Please connect the Spillway road with gravel road to Quarry and Hill 1000. c) Please provide access road to the stilling basin along the right abutment.	Chu Liu	a. The upstream slope is a temporary slope (waste soils will be placed against the slope) and should be as steep as possible. b. Concur. Road layout will be resolved during final design. c. Access to the stilling basin will be via an access road on the face of the dam.
8	Pg 7-16 Sec 7.6.7	Change (Figure 7-1) to (Figure 2-1).	Chu Liu	Concur. Will change reference to Figure 2-1.
9	Figure 7-5	What is the footprint of the stilling basin?	Chu Liu	The stilling basin has the horizontal floor on Figure 7-5. The extent of the stilling basin will be delineated on this figure.
10	Appendix D Figure D-3	Stability analysis of the downstream excavation slope of existing dam (cofferdam) is recommended to perform with reservoir water surface at approximately elevation 738 feet that would provide protection for a 100-year storm event.	Chu Liu	Concur. This is a consideration for final design.
11	Executive Summary	ES-3 implementation schedule discussion should not allow the inference that that the environmental review schedule controls the construction duration. Delete the first sentence in the 3rd paragraph, page ES-3. Also, the ES should better convey the urgency / aggressiveness' with which we are pursuing this project. Begin the 3rd paragraph, page ES-3 with: "*SFPUC is pursuing an aggressive, accelerated schedule for the Environmental Review and Design phases of this project.*"	Chris Nelson	Concur. The first sentence in the 3rd paragraph, page ES-3. will be deleted. Will add wording at end of comment.

No.	Ref. Page or Section	Comments	Reviewers	URS Response
12	1.1.1 Project Need	Consider stating the reservoir level limitation in the 3rd paragraph using the same terms that were used in correspondence from DSOD. Revise 1st sentence of the 3rd paragraph of this section and the 1st sentence of paragraph 2, page ES-1 to read: Since the winter of 2001, in response to safety concerns about the seismic stability of the dam and Mandates from the California Division of Safety of Dams (DSOD), the SFPUC has lowered water levels in Calaveras Reservoir *to elevation 705, or approximately* 39 percent of its maximum capacity."	Chris Nelson	Concur. We will insert underlined words "… *elevation 705, or approximately* 39 percent of its maximum capacity."
13	3 Design Criteria	a) Add impoundment capacity objective and explanation of spillway elevation criteria. Add bullets in section 3.2 Performance Objectives with something to the effect of: o *Nominal storage capacity will be restored the existing conditions prior to the DSOD reservoir level restriction of elevation 705.* o *Maximum pool spillway elevation will be elevation 756.* b) Design criteria are implied by reference to Appendix B. However appendix B is still quite general. Add design criteria to this section for outlet facilities accessibility and hoisting equipment, valve service and controls, site accessibility, access roads and bridges duty and service life, structures service life, instrumentation service life, etc. Also, design criteria for facilities required to treat reservoir and withdrawn water should be addressed. Although it may be too early to provide this data, a plan for its development in the design process should be documented here. Add criteria defining the service life of the dam in terms of the future maintenance cycle. Comments should be kept to conceptual level design and final design level work will more fully address these issues. c) Confirm in 2nd paragraph of section 3.3.3 that secondary faults pose no site constraints, or any criteria for dealing with them. Simply state at the end of paragraph 2, page 3-3: "*Being inactive, these faults pose no site constraints from fault displacement or ground motion.*" d) Reconcile Section 3.6 reliance upon existing outlet facilities design	Chris Nelson	a. Concur. Similar words will added in Section 3.2. b. A general description of requirements will be included in the CER to provide a placeholder for criteria related to these facilities. Detailed criteria will be developed in the early stages of design based on SFPUC input and the finalized arrangement. c. Concur. Wording will be added. d. Concur. The text will indicate that a new tower will be

No.	Ref. Page or Section	Comments	Reviewers	URS Response
		and the intention to build a new outlet tower. Rewrite the 3rd sentence in paragraph 3 of Section 3.6 to: "The *existing* inlet tower system was rehabilitated in 1991-1992 in part to address deficiencies in meeting DSOD drawdown requirements." And following that, add: "*However, from an operational and maintenance perspective, a new intake tower is preferred even though the existing structure can achieve DSOD evacuation requirements.*" Rewrite the last sentence: *In either case*, extending the outlet discharge point downstream would have minimal impact on the outlet capacity.		constructed Wording to be added.
		e) Amend section 3.6 to condition reliance upon existing outlet facilities design to avoid repeating previous design errors: Existing FCV jet containment within the dissipation basin occurs only at higher rates and isolation valve design is not appropriate for the application. Please include design criteria to avoid these problems. Add paragraph 4 to Section 3.6 to read: "*Discharge from the fixed cone valve will be directed to the spilling basin to avoid erosion of the existing pipeline and the toe of the landslide downstream of the new dam embankment. Design criteria will consider assessment of the isolation valve design application to the outlet works system.*"		e. We will add the suggested wording. We do not understand why an isolation (guard) valve is considered inappropriate for the application. Our intent is to provide a butterfly valve upstream of the fixed cone valve so that releases could continue to be made to the SVWTP when the fixed cone valve is being serviced.
		f) Sedimentation consideration mentioned in 3rd paragraph of 3.7.1 should be clarified. Rewrite portion of sentence 4 in 3rd paragraph within parentheses to read; (approximately 25,700 acre-feet not considering sediment, *which over the last 80 years has accumulated to approximately 4,850 acre feet within the reservoir*). Add a footnote on page ES-1 and page 1-1 where 96,850 acre-feet first appears and in bullet 2 on page ES-3 that reads: "*96,850 acre-feet is the storage capacity of the reservoir when first constructed in 1925. Over the last 80 years, sedimentation within the reservoir from the surrounding drainages, principally Arroyo Hondo, has reduced reservoir capacity to approximately 92,000, based on bathymetric surveys by SFPUC in 2000.*"		f. Concur. Wording to be added.

Calaveras Dam Replacement Project

Draft Conceptual Engineering Report, Volume 1, *Dam and Appurtenant Structures*
SFPUC Review Comments
October 11, 2005 (Rev)

No.	Ref. Page or Section	Comments	Reviewers	URS Response
14	6 Seismic Design Parameters	Explain what is known about the relationship of RTS equilibrium to extended drawdown of reservoirs on the order of several years to a decade. Explain, to the extent possible, that RTS does not occur in relatively shallow reservoirs and the extended drawdown at Calaveras Dam has no historical precedence for causing RTS.	Chris Nelson	Concur. We will state that RTS does not occur in relatively shallow reservoirs and the extended drawdown at Calaveras Dam has no historical precedence for causing RTS.
15	7 Replacement Project Description	a) Indicate how the decision will be made between grout curtain option and the secant wall option on left abutment in section 7.2.6. Add a sentence following sentence 1 of paragraph 2 to read: "*The decision to employ a grout curtain or a secant wall option will be further explored during the 35% design phase of the project.*" *b)* In section 7.2.7 add summary or reference to documentation of construction period stability analysis of right abutment landslide. Add sentence at end of paragraph to read: "*The landslide stabilization options will be further explored during the 35% design phase of the project.* c) Section 7.3 is very brief and relies upon reference to TM7 for justification, which might be OK, but we don't have an updated TM7 that includes the curved spillway as an option. Where is the final alternatives analysis for spillway options? TM7 was never finalized because the curved spillway concept was recommended in CTAP Meeting No 2. Report and URS response to comments contained within Appendix A to TM9.3 (Final) and was then incorporated in the URS analysis for the CER. d) The stilling basin alignment seems to increase the angle of the bend downstream or, at least, reduces the length of straight stream channel until that first bend. The discharge is directly on the toe of a landslide across which the 44" pipeline is aligned. How will the project assure that spillway operation will not washout the pipeline or trigger landsliding. The new curved spillway alignment does increase the angle of incidence to the creek alignment more than the existing spillway, but the purpose of the spilling basin will be to dissipate the energy sufficiently to eliminate downstream erosion and landslide destabilization. This will be addressed in the physical modeling during 35% design. Perhaps one of the reasons that the	Chris Nelson	a. Concur. b. Concur. c. At the suggestion of the CTAP a curved spillway alignment was considered as one means of reducing the required excavation to more closely match embankment fill requirements. In obtaining quotations for the model study, we looked at other means for achieving this goal, and thereby reduce the potential for wave development in the spillway and the need for very high spillway walls. We will add a general description of the options in the CER still being considered, but the details will not be developed until the model study. The alternatives analysis completed thus far has been to select right abutment over the left abutment and consideration of tunnel spillway alternatives. d. The flow energy will be dissipated in the stilling basin, and the flow will then be directed to the creek channel.

No.	Ref. Page or Section	Comments	Reviewers	URS Response
		existing spillway and stilling basin does not function well is the fact that no physical modeling was performed when originally designed. I know of no specific problem with the existing stilling basin design. However, stream channel stability has been proven to be tenuous at the toe of the slide, because channel reconstruction was required at one point, early in the life of the reservoir. This design may require much more stream bank armoring than other spillway/stilling basin alternatives, meaning greater permanent impacts, so I just want to be sure that we can explain why we have gone with this one.		
		e) Only crest, width and length dimensions of a chute are provided. This seems inadequate information upon which to base a cost estimate. Where are the costs estimating assumptions/structural dimensions for the spillway provided? The details are contained within Appendix F-1 Cost Estimate Backup, Item 4-Spillway.		e. The text summarizes the main dimensions of the spillway. The figures were used as a basis for quantity take-offs. Wall heights, thicknesses, etc., are included in the quantity calculation files.
		f) In section 7 explain the shift in terminology from outlet tower, a term used in previous design documents for this facility and in the scope descriptions of other current projects in the program, to intake tower. Previous SFPUC terminology calls the "Intake Tower" the "Outlet Tower" in contrast with industry convention. Provide a footnote to the first occurrence of "intake tower" in line 3 of Section 7.4 that reads: "*Previous SFPUC design drawings refer to the intake tower as the outlet tower. Industry convention adopted by the U.S. Bureau of Reclamation, U.S. Corps of Engineers and others refer to this structure as an intake tower; hence, in this report and drawings, intake tower will be used.*"		f. Concur. A footnote will be added for clarification on terminology.
		g) Clarify that 500-foot extension length of outlet conduit is from the tunnel portal in section 7.4.1. Add to the first sentence of paragraph 7.4.1 "*of the existing outlet tunnel portal.*"		g. Concur.
		h) Revise 7.4 to indicate preferred intake tower option and refer to the alternatives analysis document, which should be added to the list in section 12. There is no alternatives analysis document for the preferred option of a new tower. This option is preferred by Operations (see response to comments on Section 3.6). Rewrite the		h. Concur. Now that the new tower has been determined to be the preferred alternative, this will be stated in the text. Wording to be added.

Calaveras Dam Replacement Project

Draft Conceptual Engineering Report, Volume 1, *Dam and Appurtenant Structures*
SFPUC Review Comments
October 11, 2005 (Rev)

No.	Ref. Page or Section	Comments	Reviewers	URS Response
		last sentence of Section 7.4 to read: "*The first would involve upgrading the existing tower; the second, the preferred alternative, would consist of replacement of the existing tower with a new tower.*"		
		i) 7.6.7 description of roadwork is very skimpy, and reference to figure 7-1 is not helpful. Add details or reference to supporting documentation. Add reference notes to Figure 7-1.		i. Reference will be made to Figure 2-1 (see response to Comment 8). Notes on road closure will be added to text. Calaveras Road closure was discussed during the June 10 meeting with SFPUC in Milbrae when it was stated that closure of this road will need to be checked to see if this will be allowed by CHP, County, etc. This will be the basis of the note to be included on Figure 7-1.
16	10 Schedule	a) Acknowledge that the project schedule conforms with the WSIP Cost & Schedule Basis & Assumptions published 3/21/05. Add sentence at end of first paragraph in Section 10.1 that reads: "*This schedule conforms with the Water Supply Improvement Program schedule provided by SFPUC in March 2005.*"	Chris Nelson	a. Concur. Wording to be added.
		b) Cite the appropriate environmental analysis consultant deliverable or contract document as reference for the schedule data of tasks no. 1 through 10. Provided on Figure 10-1. It has been, or it will be?		b. Concur. Major environmental milestones will be cited.
		c) Indicate how time for review and incorporation of City comments is built into the schedule. Add sentence following 1st sentence in paragraph 2 of Section 10.1 that reads: "*The schedule shown incorporates an estimate of reasonable time for SFPUC, CTAP, and DSOD review and comment of major deliverables.*"		c. Concur. Wording to be added.
		d) Address the likelihood of DSOD final review and approval occurring within the scheduled 6 weeks and not resulting in bid documents revision. Add sentence after 2nd sentence in paragraph 3 of Section 10.3 that reads: "*Final approval from DSOD is expected to occur within a 6-week window because they will have been involved in review throughout the various stages of design and progressing from 95% to 100% design does not involve significant design changes.*"		d. Concur. Wording to be added. .

Calaveras Dam Replacement Project

Draft Conceptual Engineering Report, Volume 1, *Dam and Appurtenant Structures*
SFPUC Review Comments
October 11, 2005 (Rev)

No.	Ref. Page or Section	Comments	Reviewers	URS Response
17	Appendix B	a) This appendix, or another, should provide a similar, summary-level coverage of a reservoir maintenance program upon which detailed design is to be based: routine inspection, regular valve maintenance and exercise, dam face vegetation control, woody debris removal from the reservoir, routine settlement surveys, regular demonstration of release facilities operability, reservoir water quality management, intake (fish) screens maintenance, outlet tower moisture/gas management, routine stream channel maintenance beyond pipeline, drainage system maintenance and any monitoring of slide conditions on right abutment at the dam and further downstream of the stilling basin. 1st sentence of 2nd paragraph of section B-4 does not read quite right.	Chris Nelson	a. A section on O&M will be included at the end of Section 7. Concur. Wording to be clarified.
		b) Consider summary of '97 MOU reservoir level and release requirements in Section B-4.		b. We will include quotes of specific provisions from the MOU as appropriate in Section B-4.
		c) In several places in section B-5, the project is referred to as the Calaveras Seismic project. We should refer to the project as called out by the latest program documents issued by PDS here and throughout the report. The project name is "Calaveras Dam Replacement Project".		c. The project should be referred to as the "Calaveras Dam Replacement Project"; this will be changed.
		d) SVWTP does not normally utilize Hetchy flow as a raw water source.		d. Concur
		e) Confirm with PDS that scope of the project is to include a small diameter release valve for making releases to Calaveras Creek as asserted in section B-5 description of summer operation. (May 2005 description of the Alameda Creek Fisheries Enhancement project scope includes work at the release point.)		e. Concur that such release valve will be included in the project.
		f) Sedimentation consideration mentioned in paragraph starting "Early Fall Drawdown" should be clarified.		f. Concur
		g) Cite source of section B-5 data for Upper Alameda Creek Diversion Dam. 9,800 foot length seems very long and SFWD/HH Data book		g. 9,800 foot length was scaled from USGS map. We were asked by SFPUC to change 650 cfs to 730 cfs at a meeting

No.	Ref. Page or Section	Comments	Reviewers	URS Response
		calls out capacity as 650 second feet. h) Name the program, project or work group responsible for the investigation of operational modifications mentioned in section B-5 discussion of UACDD operation, if it is not part of this project. i) Last sentence of 1st paragraph in section B-6 would be clearer to refer to transmission from Hetchy system, rather than releases from Hetchy Reservoir. j) Clarify what active storage is as used in Section B-6 discussion of drought.		on March 9, 2004, based on the "data book" h. As discussed with the SFPUC Project Manager, it was concluded that this information would not need to be included. . i. Concur j. Discussed with Leo Bauer. He recommends leaving the statement as is because of uncertainties on what minimum pool (if any) might be required for environmental reasons.
18	Appendix F Cost Estimate	Based on other projects, the cost of valve/valve housing and chemical treatment facilities is understated.	Chris Nelson	This cost will be checked.
19	Pg 3-7	Design Storm Events: The data years included in the analysis missed a major storm. According to one of the ranchers, in 1955, a heavy snow followed by a warmer rain resulted in a major flood. Investigate affect to 100-year storm event.	Alan Johanson	Flow data are not available from the USGS for that period at the gages on Calaveras Creek or on the gage found to most closely correlate with the Calaveras Creek gages. If SFPUC has such data, please provide. This will be addressed during detailed/final design.
20	Pg 4-9	For estimating purposes, a contingency dollar amount should be added to the work at Borrow Area E to deal with unforeseen costs associated with the contamination plume.	Alan Johanson	The contaminated area will be avoided during borrow operations.
21	Pg 7-14	Does it make sense to replace soil in areas that are below the operating grade?	Alan Johanson	Placing soils below the maximum reservoir water surface was discussed during the June 10 meeting with SFPUC in Milbrae. SFPUC said that disposal of material in the reservoir is not an appealing solution and should be reconsidered, even if this is a small volume compared to the reservoir capacity. This item will need to be addressed during detailed design, when the disposal volumes are better known, and preferred disposal sites have been identified. Also, consideration will be given to placing disposal materials in exhausted borrow areas (e.g., Borrow Area E).
22	Pg 7-16	7.6.6 Water that is pumped back in to the Creek must meet stringent Bay Area Regional Water Quality requirements.	Alan Johanson	Concur. This statement will be added to the text.
23	Pg 8-8	8.5 Sediments trapped within the Reservoir can affect operational use of	Alan	With the Best Management Practices that will be required at

No.	Ref. Page or Section	Comments	Reviewers	URS Response
		the reservoir after construction.	Johanson	the site, the quantity of sediment will be much less than that which occurs from natural causes. We do not expect to see an impact on operational use after construction compared to present.
24	Appendix F-5	F-2.2.1 Contractor's efforts are "quality control" owner/CM's efforts are "quality assurance"	Alan Johanson	Concur. Wording will be changed to quality control.
25	Appendix F	On construction schedule add intermediate milestones for major construction activities.	Alan Johanson	Concur. Major intermediate milestones (e.g., for completion of grout curtain/cutoff wall; completion of embankment) will be shown on the schedule.
26	Appendix F-1	Cost Estimate Back-Up: a) Revise Page 1 ####### on total price b) Concrete unit price varies: $458 per cubic yard – slabs, $575 per cubic yard – walls, $830 per cubic yard - intake tower c) Do these prices take in to account that an on- site batch plant will probably be established to meet ACI maximum 90-minute batch times? d) $10K installation for generator looks low (include testing and training)	Alan Johanson	a. Concur. b. Concur. Prices vary depending on many factors including access, form ratios, etc. (e.g., flatwork vs. walls vs underground.) c. Yes. The prices consider an on-site batch plant. This will be stated in Section F-2. d. This estimated cost will be checked.
27	General	Has a site been established for rock crushing?	Alan Johanson	No. The specific site location for rock crushing will be the contractor's responsibility to suit its operations. Three staging areas have been located on which the rock crushing facilities could be established.

Appendix H

DSOD Letter of July 13, 2005

STATE OF CALIFORNIA – THE RESOURCES AGENCY
ARNOLD SCHWARZENEGGER, *Governor*

DEPARTMENT OF WATER RESOURCES
6 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
6) 653-5791

RECEIVED
JUL 18 2005
BY: DRogers

JUL 13 2005

File: W374.PL.IC.3 DSOD

xc: Noel Wong - URS
Chris Nelson - SFPUC
Deidre appel - SFPUC

Mr. David K. Roger, P.E., C.E.G.
Project Manager
San Francisco Utilities Commission
1155 Market Street, 6th Floor
San Francisco, California 94103

Calaveras Dam, No. 10
Alameda County

Dear Mr. Rogers:

We have reviewed the conceptual design of the Calaveras Replacement Dam Project. The design is described in the report titled, Draft Conceptual Engineering Report, Volume 1: Dam and Appurtenant Structures, by URS, Inc. The report states that the preferred alternative is to construct a new 210-foot high earth fill dam immediately downstream of the existing Calaveras Dam. The new dam would have a crest elevation at 778 feet and a reservoir elevation of 756 feet to restore the existing storage capacity of 96,850 acre-feet.

We find the proposed conceptual design acceptable. We look forward to reviewing the scope of the next phase of site exploration. Please keep us informed as the project is further developed. If you have any questions, you may contact Design Engineer Wallace Lam at (916) 227-4339.

Sincerely,

David A. Gutierrez, Chief
Division of Safety of Dams

Appendix I

Response to Comments from Bay Area Water Supply & Conservation Agency (BAWSCA)

SFPUC
WATER
HETCH HETCHY
WATER & POWER
CLEAN WATER

SAN FRANCISCO PUBLIC UTILITIES COMMISSION
Project Management Bureau – Infrastructure Division
E. Harvey Elwin, Bureau Manager
1155 Market Street, 6th Floor • San Francisco, California • 94103
(415) 551-4502 • Fax (415) 551-4695

GAVIN NEWSOM
MAYOR

RICHARD SKLAR
PRESIDENT

ANN MOLLER CAEN
CE PRESIDENT

E. DENNIS NORMANDY
ADAM WERBACH
RYAN L. BROOKS

SUSAN LEAL
GENERAL MANAGER

August 18, 2005

Ms. Nicole M. Sandkulla, P.E., Senior Water Resource Engineer
Bay Area Water Supply & Conservation Agency
155 Bovet Road, Suite 302
San Mateo, CA 94402

Subject: **Comments on Calaveras Dam Replacement Project**
Draft Conceptual Engineering Report-Volume 1

Dear Ms. Sandkulla:

Thank you for your quick response in providing comments on the Draft Conceptual Engineering Report-Volume 1 for the Calaveras Dam Replacement Project. The project team has reviewed the Bay Area Water Supply & Conservation Agency (BAWSCA) comments and provides the following general response.

We understand that BAWSCA's key comments are related to "*...the need to think ahead regarding a potential expanded reservoir when considering sizing and upgrade of the conveyance facilities.*" We appreciate BAWSCA's concern and we need to consider this in concert with the stated goals and scope of the Project.

The purpose of the Calaveras Dam Replacement Project, as defined in the San Francisco Public Utility Commission (SFPUC) Water System Improvement Program (WSIP), is to construct a new dam that meets the seismic safety standards of the California Department of Water Resources Division of Safety of Dams (DSOD) and restores the original storage capacity of the existing Calaveras Reservoir (96,850 acre-feet). The purpose of the Conceptual Engineering Report (CER) is, therefore, to identify the preferred alternative to return Calaveras Dam to its original intended service. It is desirable to design and construct a replacement dam that would not preclude the potential for a future enlargement. In this regard, a cost-effective replacement dam alternative that could accommodate a future enlarged dam would be more desirable than an alternative that could not. However, the SFPUC has no plans to enlarge Calaveras Reservoir and no funds have been set aside for enlargement of the dam and reservoir.

The Project will have the same capacity as before and will be operated the same as prior to the current mandated storage restriction. The need and scope for conveyance facilities improvements that should be included as parts of the Calaveras Dam Replacement Dam Project are being evaluated. When the studies are complete, an appropriate CER Volume II will be prepared and available for review.

The attachment presents our responses to BAWSCA's "Key Issues" and the Final Conceptual Engineering Report will include BAWSCA's comments and the responses to the key issues.

We appreciate BAWSCA's interest in this important WISP project and we look forward to your future involvement during the environmental review, detailed design, final design and construction phases of the project.

Should you have any questions on the attached responses, please do not hesitate to call me at (415) 551-4574 or send an e-mail to Drogers@sfwater.org.

Sincerely,

David Rogers

David K. Rogers, P.E., C.E.G.
Project Manager
Calaveras Dam Replacement Project

Attachment-Responses to BAWSCA's Key Issues

CC: Tony Irons, SFPUC
Harlan Kelly, SFPUC
Harvey Elwin, SFPUC
Chris Nelson, SFPUC
Michael Carlin, SFPUC
Paul Mazza, SFPUC
Sharyn Sasslafsky, SFPUC
Kathy How, SFPUC
Susan Yee, SFPUC
Gilbert Tang, SFPUC
Craig Freeman, SFPUC
Janice Hutton, SFPUC
Noel Wong, URS Corporation
Tanya Yurovsky, SRT Consultants
Dale Newkirk, Newkirk Environmental

San Francisco
Public Utilities Commission

CALAVERAS DAM REPLACEMENT PROJECT
Draft Conceptual Engineering Report
Responses to BAWSCA's Key Issues

SEAL OF THE CITY AND COUNTY OF SAN FRANCISCO

ATTACHMEMT

<<< *Responses are presented immediately after each of the BAWSCA's Key Issues.* >>>

1. ***It is difficult to review Volume 1 in the absence of Volume 2 (difficult to see the entire picture), however the new outlet pipeline mentioned in Volume 1 should be placed on an alignment to avoid crossing of the Calaveras Fault if at all possible.***

   - The report speaks of providing two outlet conduits to the SVWTP which were not discussed in Volume 1. A key consideration should be the alignment of any future conduits to avoid proximately and crossing of the Calaveras Fault. However, Volume 2 was not provided in this review, and further comment will occur when Volume 2 becomes available.

> *Response: The purpose of the Calaveras Dam Replacement Project is to construct a new dam that meets the seismic safety standards of the DSOD and restores the original storage capacity of the existing Calaveras Reservoir (96,850 acre-feet). The Project will be operated the same as prior to the current mandated storage restriction. The need and scope for conveyance facilities improvements that should be included as parts of the Project are being evaluated. However, this determination regarding conveyance will not affect the conceptual design of the dam as presented in Volume 1. The proximity of the Calaveras fault will be considered in the evaluation of alignment options if and when a Calaveras pipeline project is defined. When the studies are complete, an appropriate CER Volume II will be prepared and available for review.*

2. ***It is not clear why the maximum elevation of the dam is controlled by the existing diversion facility for planning purposes nor the adequacy of this storage to meet future planning horizons.***

   - The CER specifies that the limit of future expansion for the new dam will be set at 386,000 acre-ft based on the elevation of the diversion facility. It is silent on why this is used as the controlling criteria for this project. It is also silent on what the future storage needs are for this project and planning window to meet future supply.

> *Response: The purpose of the CER is to identify the preferred alternative to return Calaveras Dam to its original intended service. SFPUC has no plans to enlarge Calaveras Reservoir and no funds have been set aside for enlargement of the dam and reservoir. Nonetheless, it is desirable to design and construct a replacement dam that would not preclude the potential for a future enlargement. The concept resulted from the*

realization that costs to achieve this purpose are minimal compared with costs to construct a replacement dam that does not have the ability to be enlarged. In order to address this in the design, an upper limit on the size of a future reservoir had to be identified. Since there is no knowledge of whether there will be a future need for Calaveras Reservoir to be larger than the proposed 96,850 acre-feet (and if there will be a need, what size it would be), an engineering solution to the question of reservoir size was evaluated. It was determined that a "reasonable" upper limit on the elevation of a future reservoir would be 890 feet, which is the elevation of the Alameda Creek Diversion Tunnel intake. This is the highest reservoir elevation that would not require modification of the diversion facilities.

3. ***It is not clear in the report as to what will be done to remove the existing dam structure and the effects on water quality. If the existing dam is left in place permanently then what will be the impact of the existing dam failure on the new facility structure during a failure scenario?***

   - The CER is silent on the issue of what will be done with the existing dam once a new dam is built? For example, will the removal of the existing dam cause water quality concerns during demolition? If it remains in place, then what will be done to maintain water quality if the space between dams has water in it? If no water is between the old and new dam, then what will happen to the new dam if the old dam fails?

Response: *After completion of the replacement dam, the remainder of the existing dam (that had been acting as a cofferdam during construction) would be leveled off to approximately elevation 705 feet. The CER indicates that this excavated material would be placed between the downstream slope of the cofferdam and upstream slope of the replacement dam. The excavation to level off the cofferdam would be kept above the reservoir water surface. Also, during excavation to level off the cofferdam, measures such as turbidity curtains, would be used to mitigate water quality concerns. The filled area between the dam and cofferdam would need to be covered with rock materials to reduce the potential for turbidity when the reservoir level begins to inundate the fill area. The stability of the replacement dam would not be affected if the remaining portion of the old dam were to fail (e.g., during a large earthquake).*

4. ***The CER does not consider the cost to upgrade conveyance facilities to accommodate the maximum sized reservoir if accomplished now versus the future.***

   - Section 3.6 specifies that evacuation criteria of 10% volume in a 10 day period, however is silent on the evacuation criteria for the expanded facility. In other words, does the outlet pipe need expansion to accommodate future expansion? The cost of upsizing the outlet works to accommodate the 10% criteria for the future upsized facility will be minimal compared to a retrofit in the future.

Response: The outlet works would need to be expanded to accommodate a future enlargement (see CER, Appendix G, Section G-4, and Figures G-1 and G-4). As shown on Figure G-4, a new and significantly higher intake structure would be needed to extend to the enlarged reservoir water surface elevation. In addition, a new 2,700-foot long 12-foot-diamater tunnel would need to be constructed to permit evacuation of the reservoir in accordance with current DSOD criteria. These facilities were not included as part of the project because of the significant additional cost. Unlike the case for the dam, there is no potential for major savings by constructing these facilities in advance of the need for future water storage.

5. ***If the current outlet tower is used the CER does not include information on seismic stability of a vertical tower. If a new tower is constructed, there is no detail as to how this will be accomplished.***

   - It appears that the existing outlet tower will be utilized for the new dam replacement. The current tower is a vertical structure which is more subjected to seismic stability than an inclined facility such as is used in Los Vaqueros Reservoir. The report appears silent on the seismic stability of the existing tower and ability to expand for a future reservoir expansion. Collapse of the existing outlet tower can render the reservoir out of service for water supply during a time when local water supply is critical.

Response: Two options for the intake tower are presented in the CER: (1) upgrade the existing tower and (2) construct a new tower (Section 7.4.3.) Subsequent to the issuance of the CER, it was decided that a new replacement intake tower will be included in the Project. The tower concept has been accepted by the DSOD. It would be designed and constructed to accommodate the seismic loading conditions at the site (as far as such towers go, it is relatively short since most of the "tower" is actually a vertical shaft in rock).

6. ***The use of Powdered Activated Carbon (PAC) or other chemical treatments should be accommodated by providing a site in the design for future implementation.***

   - The project should consider possible use of PAC to treat reservoir water for removal of earthy musty taste and odors in the future. A suitable location for future water treatment should be identified in the new project.

Response: The determination of whether the existing potassium permanganate facility would be replaced or the use of a PAC to treat the water for taste and odors would depend on the success of the hypolimnetic oxygen system being constructed. Any water treatment facility, if required, would be placed in the flat area east of the stilling basin at the downstream toe of the replacement dam.

7. ***The current concept does not consider additional adits for better control of water quality.***

   - The outlet tower concept is limited to three adits which from a water quality perspective is very limited. Most outlet towers of this size and depth allow for at least 7 withdrawal points to accommodate reservoir level and selection of preferred zone of optimal water quality.

Response: The tower adit concept was developed to be consistent with existing operational requirements and to minimize the overall cost. Development of additional adits below Elevation 690 would require "lake tap" construction because agreements with California Department of Fish and Game preclude drawing down the reservoir below this level. Above this level, the need and potential for improved water quality versus the cost of additional adits will be considered in detailed design.

8. ***The CER should include comparisons with other recently completed reservoir projects regarding evaluation of cost contingencies.***

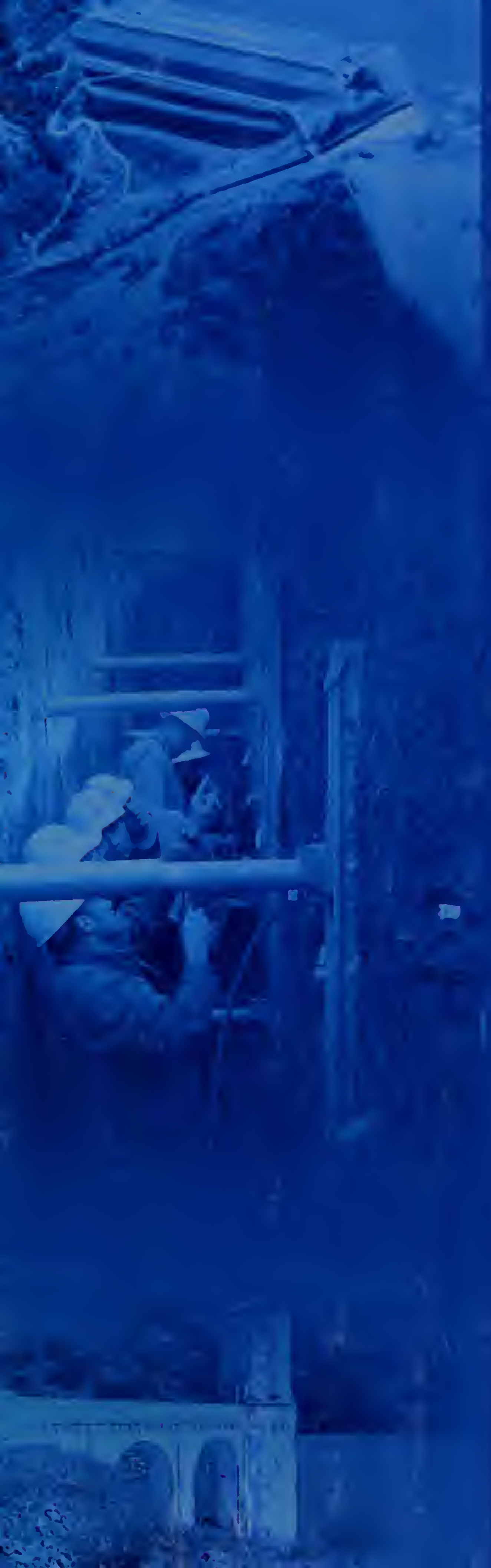
   - An analysis of other recently constructed dam projects such as Los Vaqueros Reservoir and Diamond Lake should be performed relative to cost for comparison. Diamond Lake resulted in a 40% cost over run as an example. This analysis will help further define appropriate contingencies for this project and help avoid any problems encountered with other projects.

Response: Calaveras Dam Project Team members are very familiar with the Los Vaqueros Reservoir and Diamond Lake Projects. For the CER, the design and construction contingencies were developed after consideration of the type of project and the Class 4 level of cost estimate (conceptual level of design) as defined by the Association for the Advancement of Cost Engineering. As the design of the Project is further refined, contingencies will be reviewed and revised as appropriate.

9. ***The conveyance facility has no provision for a seismically activated valve that automatically closes during an earthquake since the Calaveras Pipeline is likely to fail from information in the CER for Irvington Tunnel which will cause widespread destruction caused by free flowing water from the Calaveras Reservoir.***

   - There is no mention in the CER of the need to control free flow of water from Calaveras Reservoir in the event of a pipeline break on the Calaveras Pipeline which is a likely even in an earthquake on the Calaveras Fault from other studies. The Los Vaqueros Reservoir includes provision for a seismic activated guard valve.

Response: The conceptual design presented in the CER is at a 10% level that focused on the major costs, constructability and permitting elements. The design team, URS Corporation, for the Calaveras Dam Replacement Project is the same team that designed the seismically activated guard valve for the Los Vaqueros Reservoir. A seismically activated valve, which is a very small component of the outlet works, as mentioned and other design details will certainly be considered and developed during detailed/final design, and become available for review by SFPUC, BAWSCA and permitting agencies.



URS

1333 Broadway
Suite 800
Oakland, CA 94612